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Sewanee, Tennessee Wastewater Facilities
Volume II: Alternatives Development and Evaluation Technical Reference Document

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The quality of effluent from the existing Sewannee wastewater treatment plant does not meet the pending National Pollutant Discharge Elimination System (NPDES) permit limitations. Alternatives to the existing wastewater treatment and disposal scheme, developed to mitigate present and future water quality problems, are presented in this document.

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Environmental Impact Statement

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Sewannee, Tennessee Wastewater Facilities

Alternatives Development and Evaluation Technical Reference Document

Vol. II

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U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV. ATLANTA, GEORGIA

SEWANEE, TENNESSEE
WASTEWATER FACILITIES

ENVIRONMENTAL IMPACT STATEMENT
ALTERNATIVES DEVELOPMENT AND EVALUATION
TECHNICAL REFERENCE DOCUMENT

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WASTEWATER FACILITIES

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WILLIAM E. SOPPER, ENVIRONMENTAL SCIENTIST CONSULTANT

SEWANEE, TENNESSEE
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PART A

INTRODUCTION

1. GENERAL

The quality of effluent from the existing Sewanee wastewater treatment plant does not meet the pending National Pollutant Discharge Elimination System (NPDES) permit limitations, as documented previously in the Environmental Inventory Technical Reference Document. Alternatives to the existing wastewater treatment and disposal scheme, developed to mitigate present and future water quality problems, are presented in this document.

The existing wastewater management system is comprised of the collection sewer lines, pumping stations, and force mains; the Sewanee Utility District treatment plant; the St. Andrews School treatment plant; as well as all individual on-lot treatment and disposal facilities within the study area. Wastewater inputs to the system are the sanitary flows generated by the communities of Sewanee and St. Andrews plus the infiltration and inflow (I/I) flows which seep into the collection network.

The resulting outputs from the treatment and disposal system are point discharges from both the Utility District treatment plant and the St. Andrews treatment plant, and all nonpoint discharges from the individual on-lot septic facilities. Sludge production from these treatment processes are also system outputs, all of which must be considered in the evaluation of water quality management systems.

Alternatives developed for wastewater management systems are generally categorized into two broad areas, either structural or nonstructural in nature. In developing alternative schemes for the Sewanee wastewater system, both structural and nonstructural considerations are formulated individually to emphasize the merits and liabilities of each more comprehensively. The final alternatives selection will not be limited solely to either of these categories; it should integrate both structural and nonstructural schemes into the proposed wastewater management system.

The following sections are devoted to the development of alternative solutions to alleviate water quality problems associated with wastewater treatment and disposal in the Sewanee area. Selected treatment processes are proposed to meet wastewater effluent limitations developed by the Tennessee State Department of Health and approved by the U.S. Environmental Protection Agency (EPA).

A preliminary screening of these developed alternatives is presented in the final section of this report. Based upon compatibilities of the individually proposed alternative components, a group of alternatives are compiled which will be evaluated in more detail in the next Technical Reference Document, Alternatives Evaluation and Selection.

2. REVISION OF EFFLUENT LIMITATIONS

During the 201 Facilities Planning process, the U.S. EPA issued a tentative set of effluent limitations which differed from the Tennessee Department of Public Health's in that EPA stipulated a nitrate-nitrogen limitation whereas the State set only an ammonia-nitrogen limitation. Of concern in establishing the nitrate limitation was the protection of drinking water supplies downstream from Depot Branch (Sewanee Utility District wastewater treatment plant discharge point).

During the course of the Environmental Inventory two water quality sampling programs were conducted to establish existing conditions in the study area. These were conducted in December 1977 and April 1978. The results point to a lack of evidence that ground and surface waters in the inhabited areas near Sherwood are adversely impacted by the upstream discharge of the Sewanee Utility District wastewater treatment plant effluent. An additional sampling program was conducted in October 1978 to improve the data base to aid in making a decision on the effluent limitations, particularly for nitrate-nitrogen.

Based upon the water quality sampling results, it was decided by EPA in February 1979 that a nitrate-nitrogen limitation was not appropriate. The alternatives developed and presented in this document are based upon these newly issued effluent limitations shown later in Table III-3.

PART B

STRUCTURAL ALTERNATIVES

1. INTRODUCTION

Structural solutions to water quality degradation in the Sewanee area are those which involve the physical construction of facilities to mitigate water quality problems. Four major structural alternative categories which directly impact water quality in the study area are investigated in this section. These categories are summarized as follows:

1) A proposed future collection network and its associated service area which establishes the design size of the community treatment facility.

2) Wastewater disposal locations which may involve the pumped or gravity conveyance of effluent to streams or land application sites in the study area.

3) The wastewater treatment facilities to meet specified discharge criteria.

4) Various other structural considerations which do not fit into these first three categories.

2. COLLECTION SYSTEM AND SERVICE AREA

Service Area

The expanded collection system proposed in the 201 Facilities Plan was reviewed in conjunction with disaggregated population projections developed later in this section. These 201 - recommended sewer extensions appear to be appropriate in light of the anticipated new growth areas and those existing populated areas which are not currently sewered.

Exhibit 3 of the 201 Facilities Plan illustrates the existing and proposed extensions to the sewer system in Sewanee including the locations of three newly proposed pumping stations. Also shown are areas documented by the Franklin County Board of Health as having experienced on-lot disposal system failures. In all but two of the failure areas, the sewer extensions proposed in the 201 Plan will serve those homes and facilities having recorded on-lot failures.

The two failure areas not proposed for community sewer service in the 201 Plan are the southern side of Running Knob Hollow Lake and a group of approximately 15 homes to the southwest of Lake O'Donnell. Solutions for the problems associated with these malfunctioning systems are addressed in this section. The recommended solutions for these areas are the only deviation from the sewer extension recommendations presented in the 201 Plan.

To alleviate the septic tank problem near Running Knob Hollow Lake, it is recommended that a grinder pump unit be installed in the one home at this location. A pressure sewer should be constructed to convey the wastewater approximately 300 feet to an existing collector system.

In concurrence with the 201 Plan, it is recommended that the collection system not be expanded to the area southwest of Lake O'Donnell because of the high cost of providing service. Page VIII-18 of the 201 Plan documents the cost of extension to this area. Other alternative solutions to sewer extensions will be addressed later in this chapter to mitigate the health and water quality problems associated with repeated failures in this area.

Population and Flow Projections

On the basis of the proposed sewer extensions and disaggregated population projections as shown in Table II-29, a service population for the design year 2000 can be determined. Table III-1 lists the drainage sub-basins to be serviced by the wastewater system and the corresponding service populations for the design year. For the year 2000 an estimated 3,160 persons will be served by the collection and treatment system.

Present Sewanee Utility District policy allows some homeowners within the existing service area to continue using existing on-lot systems. Because of higher densities in these serviced areas and therefore the greater associated public health risks from malfunctioning septic systems, it is now recommended that all residences within the wastewater service area be required to connect to the community collection system, unless such a connection is judged to be infeasible.

The future sanitary flows to the Sewanee Utility District wastewater treatment plant can be determined with this future service population information and a per capita wastewater flow. The per capita wastewater flow is documented in Appendix II to be 61 gallons per capita per day (gpcd).

TABLE III-1

SEWANEE UTILITY DISTRICT WASTEWATER
SERVICE POPULATION FOR YEAR 2000

Drainage Basins and Sub-basins Within the Proposed Service Area	Year 2000 Population Served
Mud Creek Drainage Basin	
Greens View Sub-basin	327
Lost Creek Drainage Basin	
Lake O'Donnell Sub-basin	937
Barnes Branch Sub-basin	937
Upper Depot Branch Sub-basin	1,255
Boiling Fork Creek Drainage Basin	
University Sub-basin	544
Lake Cheston Sub-basin	81
U.S. 64 W Sub-basin	+ 16
TOTAL SERVICE POPULATION-	3,160

The year 2000 design sanitary flow contributed by system users is estimated to be 192,800 gallons per day (gpd), based on the design population of 3,160. Tennessee Department of Public Health standards require wastewater treatment facilities for plants less than 1 mgd to be sized for the daily flow volume occurring over an 18-hour period. Therefore, as shown in Table III-2, the design basis for the Sewanee treatment plant will be 256,400 gpd of sanitary flow, assuming the total sanitary flow occurs over the 18-hour period.

In addition to the sanitary flow contributed by users, an allowance for infiltration and inflow into the sewer system must be included in the plant capacity. For this purpose, a Sewer System Evaluation Survey (SSES) was conducted by the 201 Facilities Planning consultant. Such a survey is performed to determine the extent of extraneous ground and surface waters into the collection system. A Sewer System Evaluation Survey is normally segregated into three phases. Initially, flow measurements are recorded throughout the collection and conveyance system to determine if an I/I problem is present. If excessive I/I is revealed, a cleaning and inspection of the sewer system is conducted. Finally, an analysis is performed to determine whether repair and rehabilitation of the sewer network would be cost-effective when compared to alternatively designing a larger-sized treatment plant to accommodate the additional unrehabilitated I/I flows.

The Sewanee SSES Report recommends sewer system repairs and rehabilitation work in order to cost-effectively reduce I/I. Some of the recommended work was performed during the SSES. Based upon completion of the recommended work, future I/I quantities are projected as shown on page V-6 of the SSES Final Report dated November 1977. The projected maximum 30-day average I/I flow is 180,500 gpd.

The design capacity for the Sewanee wastewater treatment facilities, as displayed in Table III-2, is 436,900 gpd, which includes both sanitary and I/I flow components.

TABLE III-2

SEWANEE UTILITY DISTRICT WASTEWATER
TREATMENT PLANT DESIGN CAPACITY
YEAR 2000

	gallons/day
Sanitary Flow (Maximum 30-day Average) (1)	256,400
Infiltration and Inflow (Maximum 30-day Average) (2)	180,500
Total Design Flow (Maximum 30-day Average)	436,900

Note: (1) 18-hour design basis; 3,160 persons @ 61/gpcd; see Appendix II.
(2) page V-6 of SSES Final Report, November 1977.

3. WASTEWATER DISPOSAL ALTERNATIVES

Selection of treatment processes for the Sewanee Utility District wastewater facility first requires the compilation of potential discharge alternatives and their associated effluent limitations. Two general discharge alternative categories are considered for disposal of the wastewater effluent:

i) discharge to local receiving waters.

ii) discharge by means of land application.

Specifically, five receiving streams and three land application sites are initially considered.

Effluent limitations for discharge are issued by the State of Tennessee Department of Public Health and approved by EPA. The potential environmental sensitivities of the intermittent streams draining the Sewanee area (Cumberland Plateau) from the discharge of wastewater effluent are the fundamental reasons for initiation of this EIS. Issuance of appropriate effluent limitations for feasible discharge alternatives consequently are extremely critical to the development of wastewater management alternatives.

Discharge to Streams

As cited in the 201 Facilities Plan, all streams draining the Cumberland Plateau in the Sewanee area have an estimated 3-day, 20-year minimum flow of zero cfs. The effluent limitations for wastewater discharges are consequently relatively stringent based upon the zero dilution factor for these streams. As cited earlier in this document, additional potential environmental sensitivities related to the cave systems and water supplies in the Lost Creek drainage basin had resulted in the imposition of an even more stringent set of effluent limitations for that basin. As also noted previously, these limitations were revised in February 1979, and now are essentially equivalent to the limitations imposed on the other intermittent streams draining the Cumberland Plateau.

Elk River, to the north of Sewanee, has a substantial 3-day, 20-year minimum flow. Because of the greater dilution available here, effluent limitations for discharge are less stringent than those for the smaller streams on the Cumberland Plateau. The most recent effluent limitations pertaining to Elk River (August 30, 1978/Tennessee State Department of Public Health) were relaxed to secondary treatment, no longer requiring any degree of nitrification.

Table III-3 lists the effluent limitations applicable for the potential stream discharge sites in the Sewanee area. These are the effluent limitations from which the various wastewater treatment processes are later developed.

TABLE III-3

EFFLUENT LIMITATIONS FOR THE SEWANEE PLANNING AREA (1)

Parameter	Receiving Stream Treatment Level	Depot Branch I	Boiling Fork Crow, and West Fork of Battle Creek I	Elk River II
Flow (MGD)		0.43	0.36	0.60
BOD_5 (mg/1)		10	10	30
NH_3-N (mg/1)		2.0/5.0 (summer/winter)	5.0	—
D.O. (mg/1)		5.0	5.0	1.0
Suspended Solids (mg/1) (2)		15.0	15.0	30.0
Settleable Solids (mg/1) (2)		0.1	0.1	1.0
Chlorine Residual (mg/1) (2)		0.1	0.1	2.0
Fecal Coliform (per 100ml)		200	200	200

(1) Effluent limitations set by the Tennessee State Department of Public Health Division of Water Quality Control and approved by EPA, except as noted.

(2) Set by the Tennessee State Department of Public Health, Division of Water Quality Control, but not by EPA.

Land Application

As an alternative to the discharge of wastewater effluent to receiving streams much attention has recently been turned toward the idea of land application. Treatment requirements are generally in the range of secondary limitations, enabling a cost savings in the treatment portion of the overall treatment-disposal scheme.

Three general classifications of land application have been demonstrated to be effective: overland flow, spray irrigation, and infiltration-percolation. In the Sewanee area, spray irrigation appears to be the only viable option available when considering land application. Overland flow would be unmanageable because of the sloping terrain, and infiltration-percolation would be infeasible because of the shallow depths to bedrock typically encountered in this area.

No pretreatment standards have been set by the Tennessee State Department of Public Health pertaining to land application of wastewater. In the absence of any other specific standards, however, secondary treatment standards have been adopted and generally applied universally in order to insure proper treatment of wastewater in the soil system and to prevent clogging of the soil.

Much interest in spray irrigation has been generated within the University of the South's Forestry Department and by the Tennessee Valley Authority (TVA). The possibility of harvesting biomass from a spray irrigation site in the form of trees and utilizing this energy source to generate steam has been demonstrated to be feasible by TVA.

Several tentative spray irrigation sites were investigated in the Sewanee area. Initially, a site located south of Lake O'Sonnell was selected, but upon consultation with Dr. William E. Sopper of The Pennsylvania State University this idea was discounted because of potential water supply contamination.

Consideration was then given to two sites to the northwest of Sewanee, one near Armfield Bluff and the other near Rutledge Point. In a July 29, 1979 letter from the Office of the Vice-Choncellor and President, the University of the South recommended that the Rutledge Point tract be considered for the spray irrigation alternative.

4. WASTEWATER TREATMENT SYSTEMS

Introduction

As identified earlier in this report, there are two wastewater treatment plants within the defined wastewater management system. Only the Sewanee Utility District's wastewater treatment plant will be considered in the alternatives development. The St. Andrews School treatment facility was recently upgraded to meet its NPDES permit effluent limitations. The St. Andrews facility is further discussed in the next section, "Other Structural Considerations," of this report.

In this section are presented certain alternative treatment process schemes capable of producing effluents which will be compatible with the various discharge alternatives presented in the previous section.

Treatment Processes at Existing Plant Site

Based upon the previously cited effluent limitations and the continued utilization of the existing treatment plant site, the following wastewater treatment process schemes were developed to mitigate water quality problems in the Sewanee area:

Level I- Advanced + Nitrification
(BOD_5 = 10 mg/l, SS = 15 mg/l, NH_3-N = 2 mg/l/5mg/l)
Utilizing existing units

Headworks (1)
Primary clarifiers (1)
Trickling filter (recirculation added) (1)
Activated sludge units

Secondary clarifiers
Chlorine contact tanks (1)
Aerobic sludge digester

Discharge: Depot Branch, Boiling Fork Creek, Crow Creek, or the West Fork of Battle Creek.

Level I - Advanced + Nitrification

(BOD$_5$ = 10 mg/1, SS=15 mg/1, NH$_3$-N = 2 mg/1/5mg/1)
Abandoning existing units

Headworks (2)
Extended aeration units
Final Clarifiers
Chlorine contact tanks (2)
Aerobic sludge digester

Discharge: Depot Branch, Boiling Fork Creek, Crow Creek, or the West Fork of Battle Creek.

Level II - Secondary

(BOD$_5$ = 30 mg/1, SS = 30 mg/1)
Utilizing existing units

Headworks (1)
Primary clarifiers (1)
Trickling filters (recirculation added) (1)
Secondary clarifiers
Chlorine contact tanks (1)
Aerobic digesters

Discharge: Elk River or Land Application

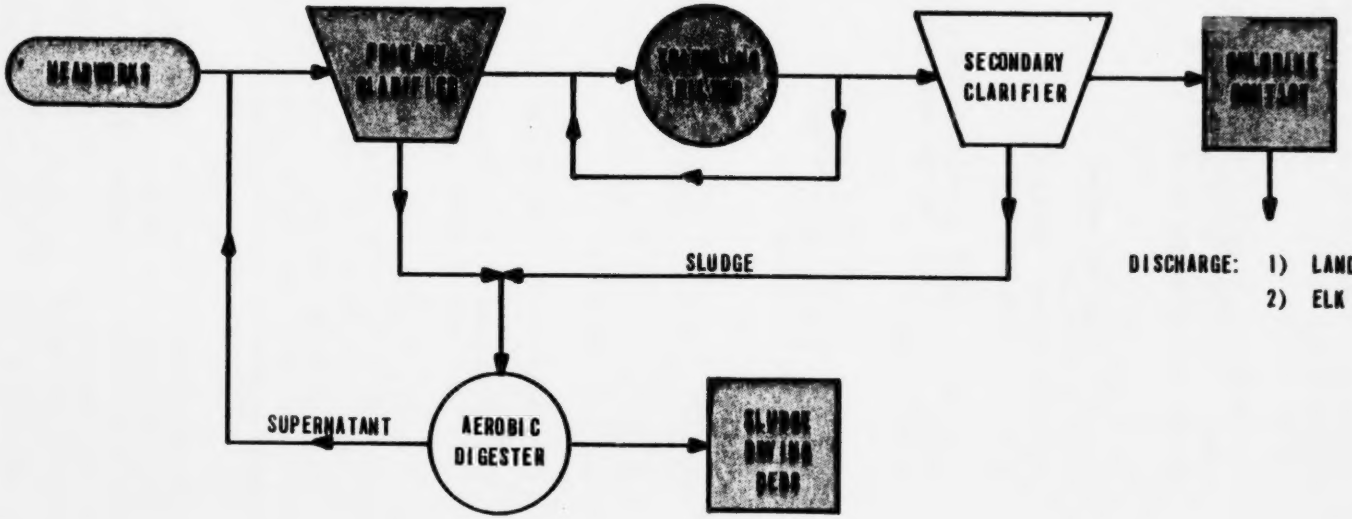
(1) Make use of existing units.
(2) Make use of existing units if possible.

Figures III-1 to III-3 show the process schematics for the two levels of treatment proposed with the plant site remaining in the Depot Branch basin. These process trains were developed with consideration given to effluent limitations for the various discharge alternatives; the existing wastewater treatment plant process units and their present condition; existing treatment plant site constraints; and reliability classifications affecting duplication of upgraded or new units, or both.

As previously described in Part D-8 of the *Environmental Inventory Technical Reference Document*, the existing Sewanee Utility District wastewater treatment plant consists of headworks, a primary clarifier, a trickling filter, an anaerobic digestor, and a chlorine contact tank. At present, none of the existing mechanical components of the units are in good condition. Replacement parts in most cases have to be fabricated. The plant site itself appears to have sufficient room for upgrading in order to meet pending effluent limitations.

FIGURE III-3

SECONDARY TREATMENT PROCESS SCHEMATIC
EXISTING PLANT SITE
LEVEL II


HEADWORKS
PRIMARY CLARIFIER
TRICKLING FILTER
SECONDARY CLARIFIER
CHLORINE CONTACT
SLUDGE
SUPERNATANT
AEROBIC DIGESTER
SLUDGE DRYING BEDS

DISCHARGE: 1) LAND APPLICATION
2) ELK RIVER

▨ EXISTING

☐ PROPOSED

SCHEMATIC DOES NOT INDICATE DUPLICATE UNITS

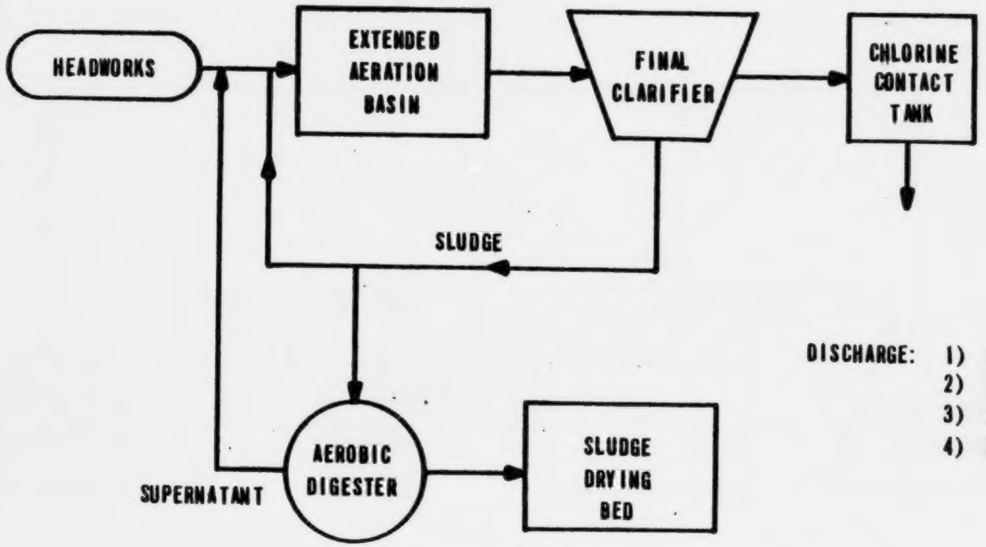
EFFLUENT LIMITATIONS

BOD_5 - 30 mg/l

SS - 30 mg/l

FIGURE III-2

ADVANCED, NITRIFICATION TREATMENT PROCESS SCHEMATIC
EXISTING PLANT SITE/ABANDONMENT OF EXISTING STRUCTURES
LEVEL I


HEADWORKS
EXTENDED AERATION BASIN
FINAL CLARIFIER
CHLORINE CONTACT TANK
SLUDGE
AEROBIC DIGESTER
SLUDGE DRYING BED
SUPERNATANT

DISCHARGE:
1) DEPOT BRANCH
2) CROW CREEK
3) BOILING FORK CREEK
4) WEST FORK OF BATTLE CREEK

EFFLUENT LIMITATIONS

BOD_5 - 10 mg/l
NH N_3- 2 mg/l/5 mg/l
(SUMMER/WINTER)

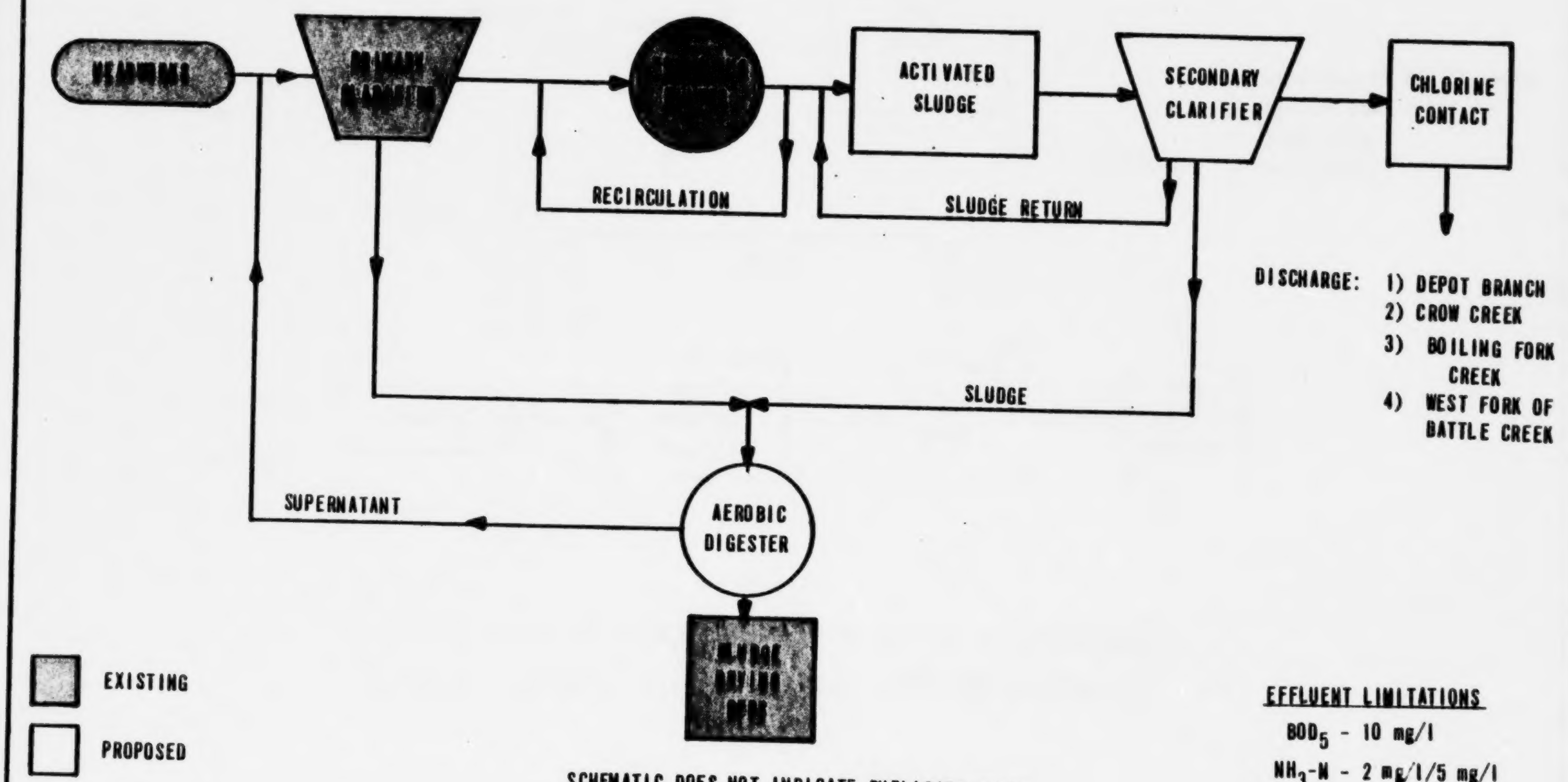
SCHEMATIC DOES NOT INDICATE DUPLICATE UNITS

FIGURE III-1

ADVANCED. NITRIFICATION TREATMENT PROCESS SCHEMATIC

EXISTING PLANT SITE

LEVEL I


HEADWORKS
PRIMARY CLARIFIER
RECIRCULATION
ACTIVATED SLUDGE
SECONDARY CLARIFIER
CHLORINE CONTACT
SLUDGE RETURN
SLUDGE
SUPERNATANT
AEROBIC DIGESTER
SLUDGE DRYING BEDS
EXISTING
PROPOSED

DISCHARGE:
1) DEPOT BRANCH
2) CROW CREEK
3) BOILING FORK CREEK
4) WEST FORK OF BATTLE CREEK

SCHEMATIC DOES NOT INDICATE DUPLICATE UNITS

EFFLUENT LIMITATIONS

BOD_5 - 10 mg/l

NH_3-N - 2 mg/l/5 mg/l

(SUMMER/WINTER)

Consideration must be given in the development of process alternatives to the reliability of the proposed treatment system. Reliability is the measurement of the ability of a component or system to perform its designated function without failure. As set forth in the EPA publication Design Criteria for Mechanical, Electric, and Fluid System and Component Reliability, almost all of the above process trains fall under Reliability Class II. The one exception is the spray irrigation alternative presented under Level II treatment. This land application alternative comes under Reliability Class III criteria. Such reliability classifications stipulate which process units require duplication in order to meet this specified degree of system reliability.

Reliability criteria will affect the proposed treatment process alternatives in the following manner:

1.) Level I - Advanced + Nitrification
Utilizing existing units (Class II)

    a.) At present only one primary clarifier exists; an additional unit will have to be added.

    b.) The combination of the existing trickling filter and the proposed activated sludge units will, as a system, meet reliability criteria.

    c.) Two secondary clarifiers will need to be constructed.

2.) Level I - Advanced + Nitrification
Abandoning existing units (Class II)

    a.) Dual extended aeration basins will be required.

    b.) Duplication of the secondary clarifiers is required.

3a.) Level II - Secondary (discharge to Elk River)
Utilizing existing units (Class II)

    a.) Only one primary clarifier exists; an additional unit will have to be added.

    b.) A second trickling filter will have to be added to supplement the one existing.

    c.) Two secondary clarifiers will have to be constructed.

3b.) Level II - Secondary (discharge to land application)
Utilizing existing units (Class III)

    a.) The existing trickling filter will be sufficient; however, an additional primary clarifier and two secondary clarifiers will be required.

The fact that some existing units have to be duplicated to meet reliability criteria is the main consideration in proposing the abandonment of the existing plant units. Integrating new units within the existing plant scheme may be more costly in the final analysis than construction of a new treatment plant on the same site. These two options will be compared in the "Evaluation and Selection" Section of the Alternative Development Document.

Under all proposed alternatives, the anaerobic sludge digester is to be abandoned and replaced by an aerobic digester. The present condition of the existing anaerobic digester is poor. This added to the fact that under the Tennessee State Department of Public Health requirements a secondary digester would be required leads to recommendation of an aerobic digester. Although somewhat higher operational costs can be expected for aerobic digestion, the ease of operation and reliability associated with it makes it a more feasible alternative to anaerobic digestion.

Sludge treatment under all proposed alternatives involves aerobic digestion with sludge drying on open beds followed by land disposal. The University of the South has previously used the dried sludge as a soil conditioner on its grounds. This practice, which proved to be satisfactory in the past, is expected to be continued.

Alternative Treatment Plant Site Considerations and Proposed Processes

The proposition of relocating the wastewater treatment plant to the Morgans Steep area of Sewanee has elicited much criticism both from the University and individual homeowners. In light of the recently revised effluent limitations, there is no longer the advantage of the reduced treatment requirements realized in relocating the treatment plant from the Depot Branch basin to one of the other three intermittent stream basin locations. For these reasons, the alternative of relocating the treatment plant to any of the other intermittent stream basins shall no longer be considered.

If upon evaluation it later appears that the spray irrigation alternative is within the cost-effectiveness range of the other proposed treatment discharge alternatives, the possibility of relocating the treatment plant to the vicinity of the spray irrigation site will be further investigated. Relocation of the plant to the spray irrigation site would offer the advantage of consolidation of maintenance at one site for both the spray equipment and treatment plant. The following is the process scheme proposed for this new plant:

4.) Level II - Secondary
(BOD_5 - 30 mg/1, SS = 30 mg/1)
New plant site at Rutledge Point

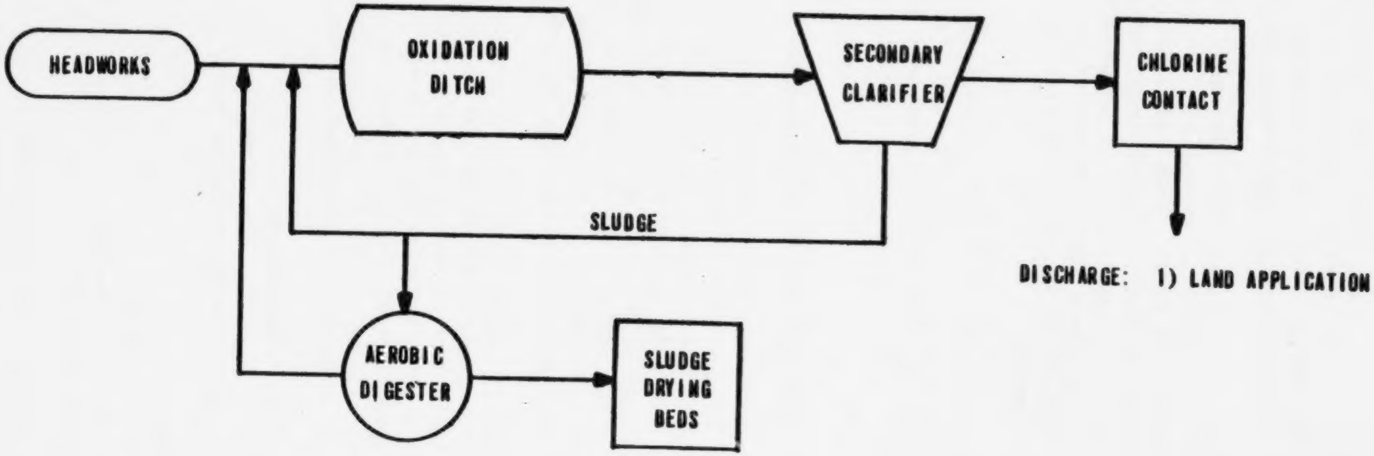
Headworks
Oxidation ditch
Secondary clarifiers
Aerobic digester

Discharge: Rutledge Point spray irrigation site

This process scheme is of Reliability Class III and therefore only requires duplication of the secondary clarifiers. Figure III-4 shows this process schenatic.

FIGURE III-4

SECONDARY TREATMENT PROCESS SCHEMATIC
NEW PLANT SITE
LEVEL II


HEADWORKS
OXIDATION DITCH
SECONDARY CLARIFIER
CHLORINE CONTACT
SLUDGE
AEROBIC DIGESTER
SLUDGE DRYING BEDS
DISCHARGE: 1) LAND APPLICATION

SCHEMATIC DOES NOT INDICATE DUPLICATE UNITS

EFFLUENT LIMITATIONS

BOD_5 - 30 mg/l
SS - 30 mg/l

Flow Equalization

Consideration was given in the 201 Plan to provision of a detention pond for attenuating extreme flows entering the treatment plant. The 50-year, 7-day and 100-year, 7-day storm events considered in the 201 analysis, while appropriate for protection of treatment facilities from stream flooding, are not appropriate for design sizing of equalization basins.

For the purposes of reducing extreme flows through treatment units, a 2-year return frequency for the 7-day rainfall event is a more reasonable design criterion. U.S. Department of Commerce statistical data documented in Appendix II indicate the 2-year, 7-day storm event will produce 6 inches of rain precipitation in the Sewanee area.

The methodology utilized in the 201 Facilities Plan for estimating inflow volumes based on rainfall quantities is presented in the SSES Final Report. The methodology is based on a correlation between total rainfall for storm events in the Sewanee area and metered volumes of inflow to the collection system. Using this relationship, an equalization basin of 993,300 gallons of storage capacity is sized for the extreme rainfall events cited in the 201 Plan.

However, using the 2-year return frequency rainfall event recommended in this EIS, a 497,000-gallon equalization basin is found to be appropriate. This analysis is documented in Appendix II.

For the evaluation of alternatives, such an equalization basin will be included in the cost estimate for all proposed process trains. However, the basin design should be reevaluated before final detailed design of the wastewater treatment plant, focusing on the possibility of further decreasing the size of the basin or eliminating it entirely. In its efforts to correct inflow to the collection system, the Sewanee Utility District has significantly reduced such extraneous flow since the SSES Report was concluded. With such a continued maintenance and repair program of the collection system, the inflow problem may possibly be abated to the point where an equalization basin will not be necessary.

5. OTHER STRUCTURAL ALTERNATIVES

Because of the rural setting of many outlying areas compared to the more densely populated campus area in Sewanee, on-lot wastewater systems must be relied upon for continued service in many areas. The issue of continued use of septic systems to achieve prescribed water quality levels in the Sewanee area is addressed in this section. Wastewater treatment and disposal for St. Andrews is also addressed here.

On-Lot Wastewater Systems

The Sewanee Utility District wastewater treatment facilities will serve 75 percent of the planning area population by the year 2000 (see Tables II-29 and III-1). The remaining 25 percent of the population may contribute to water quality degradation in the area due to their continued use of on-lot systems.

Malfunctioning of on-lot septic systems results from a physical or biological failure of the system. This may be due to improper maintenance procedures, inadequate design, inadequate absorption field properties, or a variety of other factors. Degradation of both groundwater and stream water quality may result from such malfunctions.

The Cumberland Plateau region is characterized by shallow depths to bedrock. Generally, in and around the Sewanee area, septic tank absorption fields perform inadequately due to these shallow soil depths. It is recommended that septic system users in those areas with soil limitations that are not proposed to be included within the community sewer collection system be required to modify any existing on-lot systems considered to be malfunctioning. An evaluation of those septic systems in the study area which are slated for continued service under the EIS-recommended collection system extensions should be conducted to determine their present adequacy.

Where soil depth has been the limiting factor, sand mounds have successfully been used in remedying malfunctioning septic systems. In cases where sand mounds are being considered and the population density in the area is sufficiently enough, the potential for a more cost-effective community-shared sand mound absorption field may exist. In such cases, the wastewater leaving the individual septic tanks would be conveyed to a nearby community mound.

The group of 15 homes southwest of Lake O'Donnell which was evaluated in the 201 Plan to be not cost-effective for community wastewater service would be an excellent case for evaluation of the cost-effectiveness of individual sand mound systems as compared to a community-size mound system. The Franklin County Health Department has specifically identified this area as a health problem because of the malfunctioning on-lot systems. Other such clustered areas may also exist which have on-lot problems not yet identified. If so, they too should be evaluated for the community-size mound absorption field system.

St. Andrews Wastewater Facilities

St. Andrews School has recently upgraded its extended aeration package treatment plant to comply with EPA and Tennessee State effluent regulations. With the treatment plant now in compliance of effluent limitations, it is recommended that St. Andrews continue its present operations.

The 201 Plan makes these same recommendations based upon St. Andrews proposed actions to achieve compliance and the adverse environmental impacts anticipated in constructing a force main from the package plant to the Sewanee Utility District wastewater treatment plant.

PART C

NONSTRUCTURAL CONSIDERATIONS

Nonstructural alternatives can provide a means for attainment and maintenance of water quality standards without the physical construction of structural wastewater collection and treatment facilities or other wastewater facilities. While nonstructural alternatives may in some cases eliminate the need for construction of facilities, their most effective application is generally in supplementing the structural alternatives to be constructed. Nonstructural alternative considerations to be investigated for application to the Sewanee area are presented in this section.

1. IMPROVED OPERATION AND MAINTENANCE

Improved operation and maintenance techniques are commonly cited as nonstructural measures which can improve effluent quality while making use of existing facilities. The presence of large visible floating solids at the outfall to Depot Branch is an indication that the plant could be better operated to prevent such discharges. While Sewanee treatment plant performance summary data indicate that the plant is meeting secondary treatment requirements, such observed discharge violations substantiate the case for improved operation and maintenance of the facilities.

Maintenance of the process units, particularly the clarifier and trickling filter, is reported in the 201 Facilities Plan to be a major problem. Performance of the plant is affected by malfunctioning of these units due to the age of the various mechanical equipment. If these units are to be integrated into the recommended alternative selection, replacement of many of their components will be necessary.

Improved operation and maintenance of the existing facilities, while presently called for to meet the secondary treatment standards for which the plant was originally designed, cannot be expected to achieve the more stringent effluent limitations without physical alterations of the facilities.

2. FLOW AND WASTE REDUCTION MEASURES

Based upon water consumption data for the Sewanee area, a consumption figure of 61 gpcd has been utilized in wastewater flow projections to determine the design size of the treatment plant. With a national trend toward increased per capita water consumption, efforts should be made to at least maintain the per capita water consumption in Sewanee at its present level. Water conservation habits should be encouraged in the community through an increased awareness of the overall cost and environmental implications of increased water usage together with establishment or modification of the plumbing codes.

All future construction within the domain of the University of the South should be required, through a plumbing code mechanism, to install flow reduction plumbing fixtures. Lower flow shower heads, faucets, and toilets are the primary fixtures which, if installed in future construction and replacement of existing fixtures, could reduce water consumption and wastewater flows.

Rehabilitation of and repairs to the the collection system have reduced infiltration and inflow quantities which enter the treatment plant. A continued surveillance program of the I/I situation should be maintained in order to keep these extraneous flows to a minimum. Some means of root removal or inhibition should be conducted periodically since the SSES report indicates that root growth is a major factor in the I/I problem. The present Sewanee Utility District personnel have shown themselves to be fully competent in performing such periodic maintenance of the collection system and it is recommended that they continue this work.

3. MANAGEMENT DISTRICT CONCEPTS

One of the more promising nonstructural alternatives to aid in mitigation of water quality problems in the Sewanee area is the institution of an on-lot wastewater disposal management district. An on-lot management district typically includes all residences which maintain on-lot septic systems as their means of wastewater treatment and disposal. The objective of such a management district is to oversee and inspect the construction and maintenance of all septic systems and soil absorption systems within its jurisdictional boundaries. This concept of on-lot management is becoming more and more attractive to those areas where the pollution density does not warrant a conventional wastewater collection and treatment system; yet, health and general water quality problems result from the continued use of on-lot systems.

In addressing structural alternatives for malfunctioning septic systems in the Sewanee area, elevated sand mound absorption fields are proposed to rectify the problems on on-lot disposal due to shallow soil depths. In order to provide more effective continued use of such on-lot systems, the nonstructural approach of a management district is recommended.

Even with properly constructed on-lot disposal systems, the removal of solids and general physical repair to septic systems are often ignored until visible or odor-related indicators appear. Through an effectively organized program of regular inspection and maintenance, the efficiency of on-lot systems can be maintained.

The management district would be responsible for the following:

1. Evaluating existing on-lot system design and operation, and determining, in cooperation with the Franklin County Health Department, those systems incapable of operating properly.

2. Financing and constructing alternative on-lot systems (individual sand mounds, community sand mounds, etc.) for those systems requiring such modifications.

3. Evaluating design requirements, and financing and constructing all new on-lot disposal systems in the district.

4. Inspecting and overseeing periodic maintenance of all on-lot systems in the district.

The precise responsibilities and authority of the on-lot management district are dependent upon the institutional and financial arrangements provided with its formation. These details would be determined jointly by the Sewanee Utility District and the University of the South

The on-lot wastewater management district could be formed within the existing Sewanee Utility District structure. Operation by the Utility District offers the advantage of treatment and disposal of septic wastes, when required, at the wastewater treatment plant. A separate on-lot management charge could be established for these customers.

PART D

PRELIMINARY SCREENING OF ALTERNATIVES

Various wastewater treatment and disposal alternatives for the Sewanee Utility District have been identified in this document. These alternatives involve two plant sites with discharge to five streams (requiring two levels of effluent quality) as well as disposal by land application. A detailed screening of treatment and disposal alternatives will be conducted in the next Technical Reference Document, Alternatives Evaluation and Development based upon cost, environmental considerations, implementability, and operability considerations. At this time however, certain alternatives can be eliminated through screening because of obvious cost and environmental disadvantages. This section presents the preliminary screening to eliminate the less desirable alternatives from further analysis, simplifying the later detailed evaluation.

The preliminary screening is directed at eliminating consideration given to treatment Level I discharge into Boiling Fork Creek, Crow Creek, and the West Branch of Battle Creek in favor of discharge to Depot Branch for Treatment Level I. As Table III-3 shows, only the ammonia-nitrogen effluent limitation differs for these two discharge groups. The wastewater treatment plant design would consequently only differ in the sizing of the activated-sludge aeration basins for these two discharge alternative groups. The idea of pumping to Boiling Fork Creek, Crow Creek, or the West Branch of Battle Creek is unattractive because of the operation and maintenance aspects of effluent pumping as well as the negative environmental impacts of routing a force main to any of these three creeks from the wastewater treatment plant. Consequently, preliminary screening favors the slightly higher treatment requirement associated with discharge to Depot Branch when compared to discharge to the other three intermittent creeks.

The wastewater management alternatives listed below are therefore, those which will be later evaluated in detail:

Discharge to Depot Branch:
1.) Treatment Level I
    Utilization of existing units
2.) Treatment Level I
    Abandonment of existing units

Discharge to Elk River:
3.) Treatment Level II
    Utilization of existing units
Land Application:
4.) Treatment Level II
    Utilization of existing units
5.) Treatment Level II
    Relocation of treatment plant to
    Rutledge Point area.

SEWANEE, TENNESSEE

WASTEWATER FACILITIES

ENVIRONMENTAL IMPACT STATEMENT ALTERNATIVES EVALUATION TECHNICAL REFERENCE DOCUMENT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

ATLANTA, GEORGIA 30365

ENVIRONMENTAL IMPACT STATEMENT
ALTERNATIVES EVALUATION TECHNICAL REFERENCE DOCUMENT
SEWANEE, TENNESSEE
WASTEWATER FACILITIES

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APPENDIX A

"AUGER BORING INVESTIGATION FOR THE PROPOSED SPRAY IRRIGATION SITE - SEWANEE, TENNESSEE"
SOIL SYSTEMS, INC.

APPENDIX B

"EVALUATION OF POTENTIAL SITES FOR FOREST SPRAY IRRIGATION SYSTEM - SEWANEE, TENNESSEE"
WILLIAM E. SOPPER, ENVIRONMENTAL SCIENTIST CONSULTANT

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ALTERNATIVES EVALUATION

PART A. INTRODUCTION

Based upon the wastewater treatment and disposal alternatives and the other wastewater management considerations presented in the Alternatives Development Technical Reference Document, five wastewater management alternatives were developed. During the course of the evaluation for the selected alternative, changes were made to some of the original alternatives and two new alternatives were added to the list for evaluation. This development was due to changes in some of EPA's guidelines, feedback from the public and government officials of the Sewanee Study Area, and consideration of results from spray irrigation site investigations.

A major issue that caused revisions and additions to be made to the originally developed alternatives concerns the lessened pre-application treatment requirements for spray irrigation. A Level B pre-application treatment is recommended by EPA Region IV as defined in the Construction Grants Program Requirements Memorandum (PRM) 79-3. This level is defined as biological treatment by lagoons plus control of fecal coliforms to less than 1,000 MPN/100 ml. This significantly reduces the costs associated with land application thereby making it a more viable alternative.

Three sites; Rutledge Point, St. Marys, and Garnerstown, were proposed as possible spray irrigation sites. Dr. William E. Sopper of The Pennsylvania State University was consulted to prepare a site evaluation report (Appendix B) to determine the feasibility for disposal of treated wastewaters by forest-spray irrigation at these sites. To aid him in his assessment of the sites, Dr. Sopper referred to a report on the auger boring investigation (Appendix A) prepared by Soil Systems, Inc. (SSI). The SSI report included documentation of the results from a series of 56 auger borings on the three sites. These borings were used to determine the thickness and nature of the soil and prevailing groundwater conditions at each site. The results of Dr. Sopper's evaluation report indicated that the physical and hydrological properties of the soil and topography at the sites were quite acceptable for a spray irrigation system. The results also indicated that application rates up to 3 inches per week would be feasible.

The Rutledge Point site was then discounted due to the possible interference land application of the treated wastewaters may have on the recreational uses at the site, as expressed by the University of the South. Only two sites remained available, St. Marys and Garnerstown. These sites are also attractive considering their close proximity to the existing wastewater treatment plant. It has tentatively been decided that the St. Marys site (90 acres) would be used as the principle irrigation site while the Garnerstown site (75 acres) would be used as a stand-by. It should be noted that, even though Rutledge Point is no longer a potential site, the alternatives (4 and 5) that developed using it are still considered in this evaluation of alternatives.

The seven alternatives identified to be evaluated in detail for the selection of a water quality plan of action are as follows:

Alternative 1 - Discharge to Depot Branch; Utilization of Upgraded Existing Process Units
Alternative 2 - Discharge to Depot Branch; Installation of New Process Units at Existing STP Site
Alternative 3 - Discharge to Elk River; Utilization of Upgraded Existing Process Units
Alternative 4 - Spray Irrigation at Rutledge Point Site; Utilization of Existing Process Units
Alternative 5 - Spray Irrigation at Rutledge Point Site Installation of Facultative Lagoon at Land Application Site
Alternative 6 - Spray Irrigation at St. Marys and Garnerstown Sites Utilization of Existing Process Units
Alternative 7 - Spray Irrigation at St. Marys and Garnerstown Sites Installation of Facultative Lagoon at Land Application Site.

Detailed descriptions of these alternatives are provided in Part B. Configurations of each of the seven alternatives appear in Figure IV-1. This document then develops the methodology for the evaluation of the alternatives based upon several factors.

The cost-effectiveness principle, which is utilized as an alternative evaluation mechanism, requires the final selection of the wastewater treatment management system which results in the minimum total resources costs throughout the planning period. Several factors, both monetary and non-monetary in nature, are considered in the evaluation of the total resources costs. For the proposed Sewanee Utility District wastewater project, the following four characteristics are the factors considered in the overall cost-effectiveness evaluation:

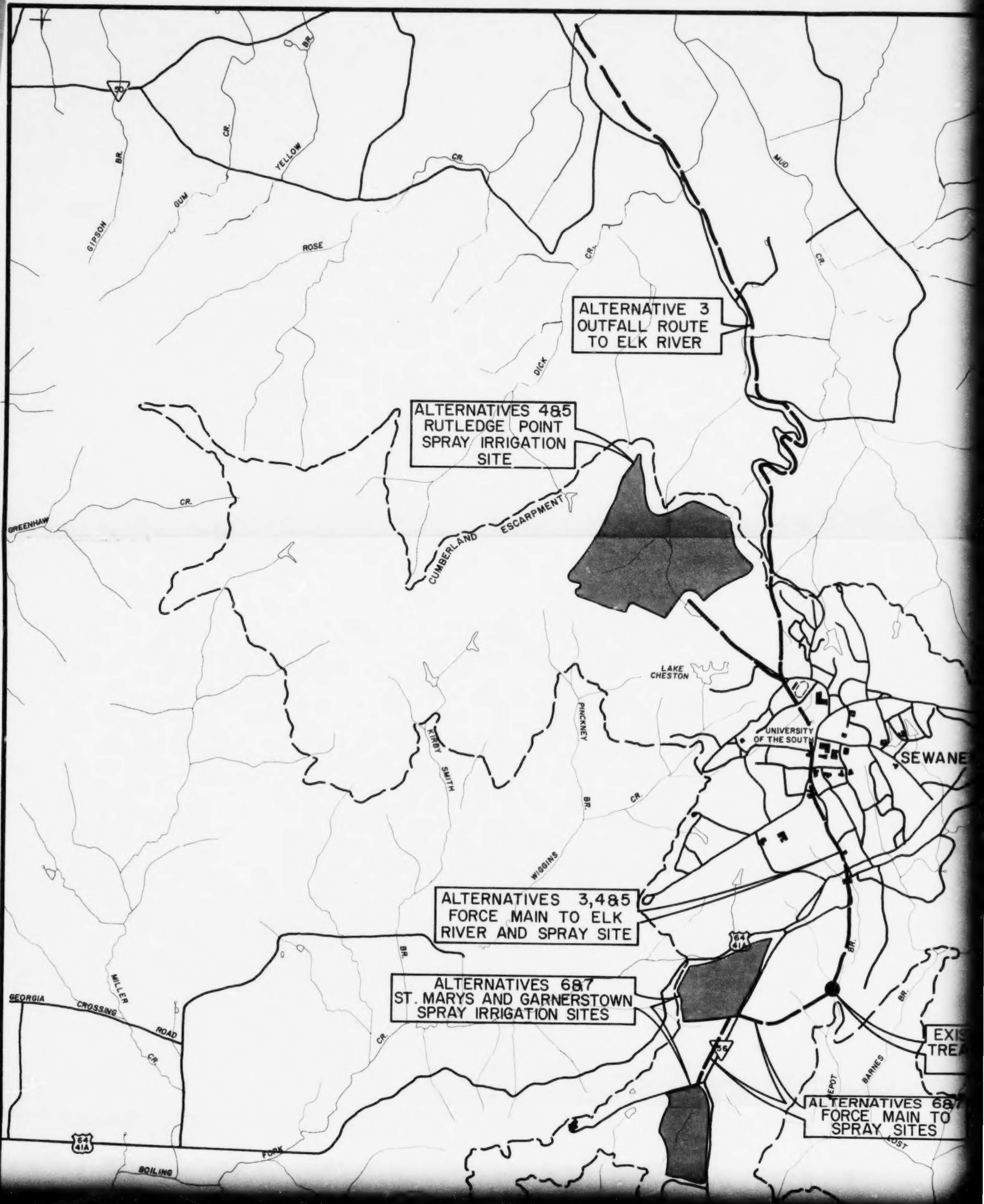
1. Cost

2. Operability

3. Environmental Consideration

4. Implementability

Each of the seven proposed alternatives is to be ranked in the order of its "resources costs" as prescribed by the EPA cost-effectiveness analysis guidelines (Subpart A, 40 CFR Part 35). The most desirable alternative in each of the four categories is that which results in the "least cost."



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YELLOW
BR.
CR.
GIPSON
BR.
GUM
CR.
ROSE
CR.
MUD
CR.
DICK
CR.
ALTERNATIVE 3 OUTFALL ROUTE TO ELK RIVER
ALTERNATIVES 4&5 RUTLEDGE POINT SPRAY IRRIGATION SITE
GREENHAW
CR.
CUMBERLAND ESCARPMENT
LAKE CHESTON
KIRBY SMITH
PINCKNEY
BR.
CR.
UNIVERSITY OF THE SOUTH
SEWANE
WIGGINS
ALTERNATIVES 3,4&5 FORCE MAIN TO ELK RIVER AND SPRAY SITE
64 41A
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ALTERNATIVES 6&7 ST. MARYS AND GARNERSTOWN SPRAY IRRIGATION SITES
GEORGIA CROSSING ROAD
MILLER
CR.
CR.
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EXIS TREA
DEPOT
BARNES
ALTERNATIVES 6&7 FORCE MAIN TO SPRAY SITES
LOST
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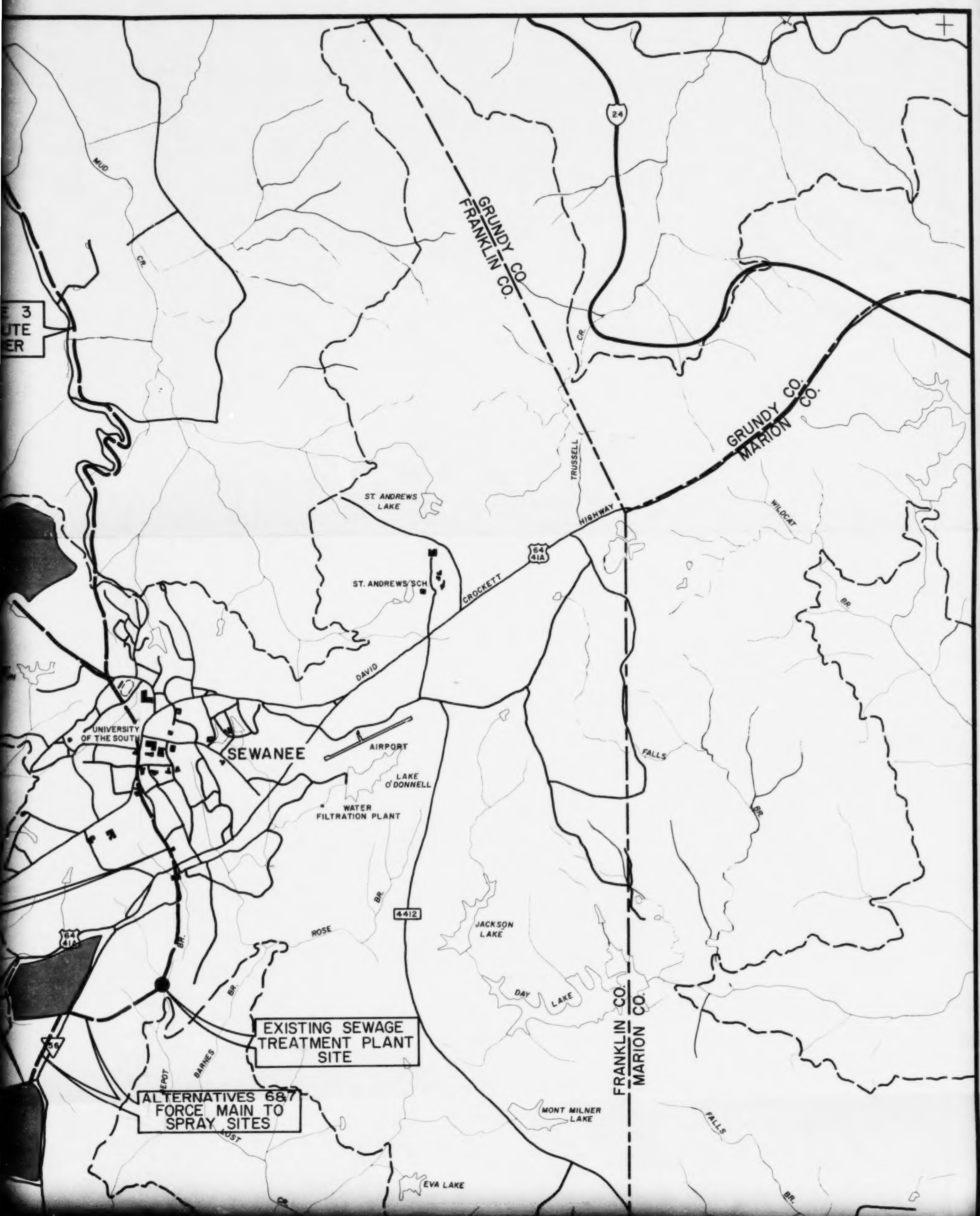
FORK
BOILING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GRUNDY CO.
FRANKLIN CO.
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CR.
TRUSSELL
GRUNDY CO.
MARION CO.
ST. ANDREWS LAKE
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41A
WILDCAT
ST. ANDREWS SCH.
CROCKETT
BR.
DAVID
UNIVERSITY OF THE SOUTH
SEWANEE
AIRPORT
LAKE O'DONNELL
FALLS
WATER FILTRATION PLANT
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BR.
4412
ROSE
JACKSON LAKE
64
41A
BR.
BR.
DAY LAKE
FRANKLIN CO.
MARION CO.
EXISTING SEWAGE TREATMENT PLANT SITE
56
DEPOT
BARNES
ALTERNATIVES 6&7 FORCE MAIN TO SPRAY SITES
MONT MILNER LAKE
LOST
FALLS
EVA LAKE
CR.
BR.

UNDY CO.
ARION CO.
WILDCAT
BR.

ALTERNATIVE DESCRIPTION

ALTERNATIVE 1 — UTILIZATION OF UPGRADED EXISTING PROCESS UNITS
DISCHARGE TO DEPOT BRANCH

ALTERNATIVE 2 — INSTALLATION OF NEW PROCESS UNITS AT EXISTING STP SITE
DISCHARGE TO DEPOT BRANCH

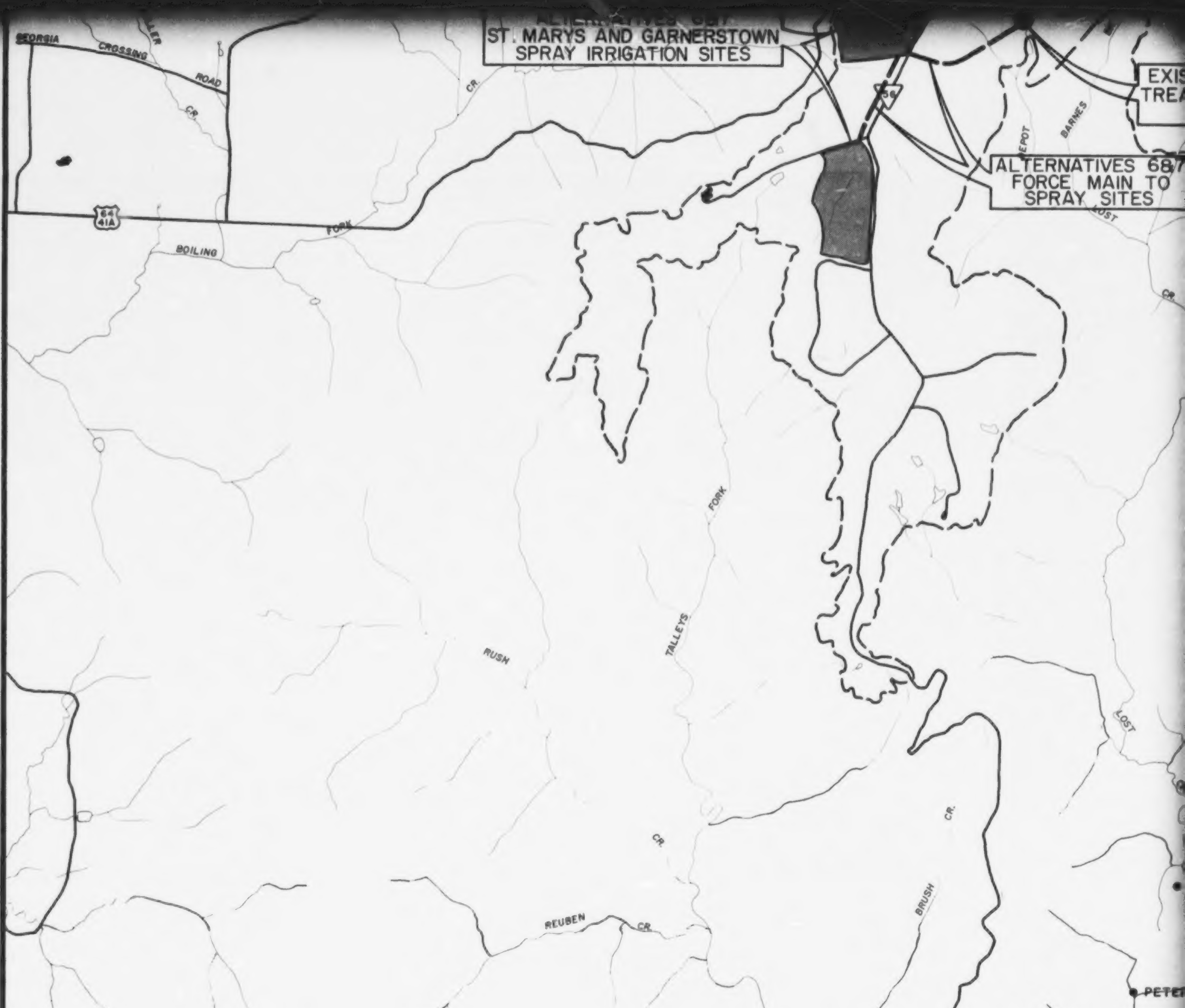
ALTERNATIVE 3 — UTILIZATION OF UPGRADED EXISTING PROCESS UNITS
DISCHARGE TO ELK RIVER

ALTERNATIVE 4 — UTILIZATION OF EXISTING PROCESS UNITS
SPRAY IRRIGATION AT RUTLEDGE POINT SITE

ALTERNATIVE 5 — INSTALLATION OF FACULTATIVE LAGOON AT LAND APPLICATION SITE
SPRAY IRRIGATION AT RUTLEDGE POINT SITE

ALTERNATIVE 6 — UTILIZATION OF EXISTING PROCESS UNITS
SPRAY IRRIGATION AT ST. MARYS AND GARNERSTOWN SITES

ALTERNATIVE 7 — INSTALLATION OF FACULTATIVE LAGOON AT LAND APPLICATION SITE
SPRAY IRRIGATION AT ST. MARYS AND GARNERSTOWN SITES


ALTERNATIVES 6&7
ST. MARYS AND GARNERSTOWN
SPRAY IRRIGATION SITES
EXIS
TREA
ALTERNATIVES 6&7
FORCE MAIN TO
SPRAY SITES
GEORGIA
CROSSING
ROAD
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CR.
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41A
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FORK
DEPOT
BARNES
LOST
CR.
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RUSH
TALLEYS
FORK
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LOST
BRUSH
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DRY
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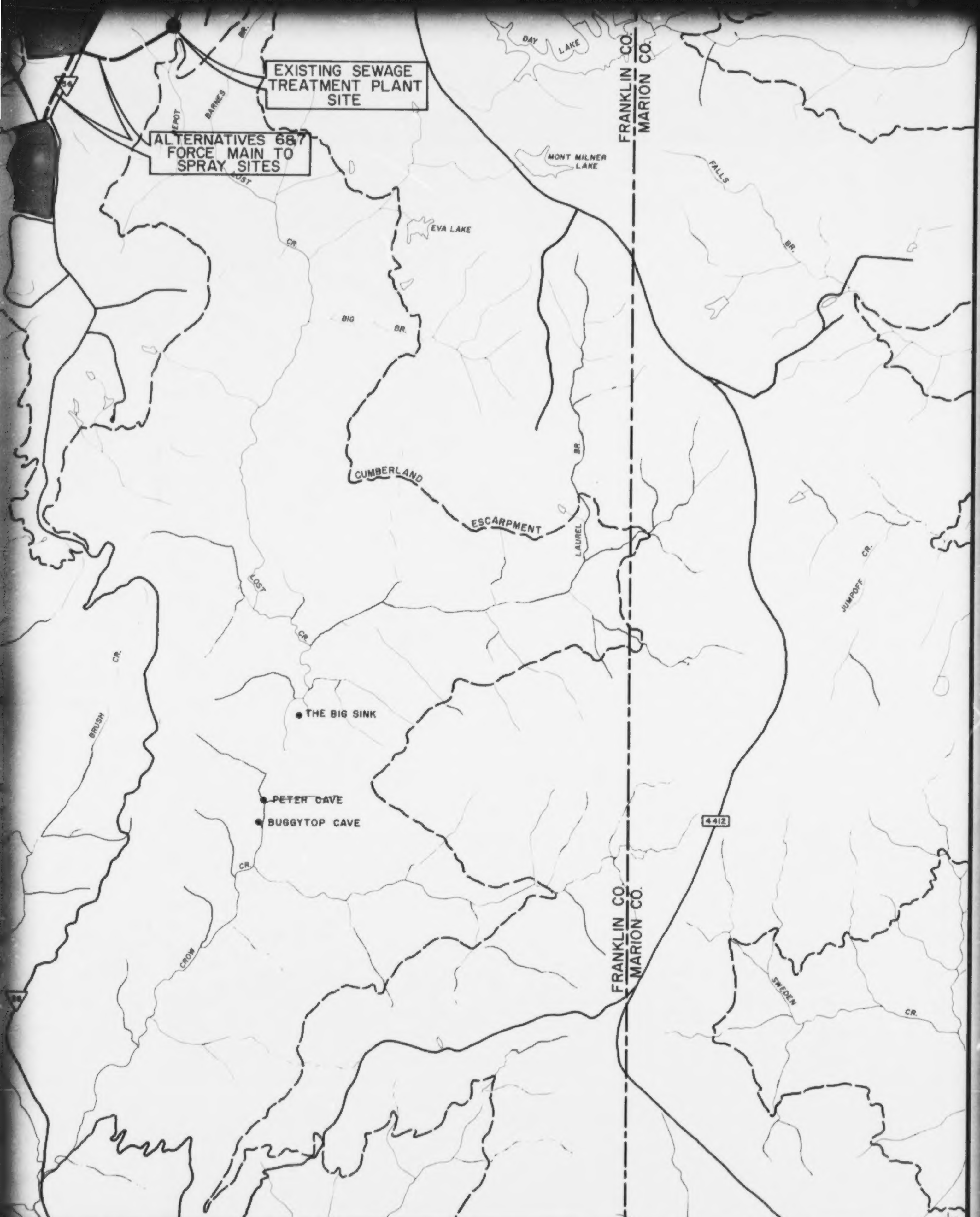
EXISTING SEWAGE TREATMENT PLANT SITE
ALTERNATIVES 6&7 FORCE MAIN TO SPRAY SITES
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FRANKLIN CO.
MARION CO.
MONT MILNER LAKE
FALLS
BR.
LOST
CR.
EVA LAKE
BIG
BR.
CUMBERLAND
ESCARPMENT
BR.
LAUREL
LOST
CR.
JUMPOFF
CR.
BRUSH
CR.
THE BIG SINK
PETER CAVE
BUGGYTOP CAVE
CR.
CROW
4412
FRANKLIN CO.
MARION CO.
SWEDEN
CR.
56

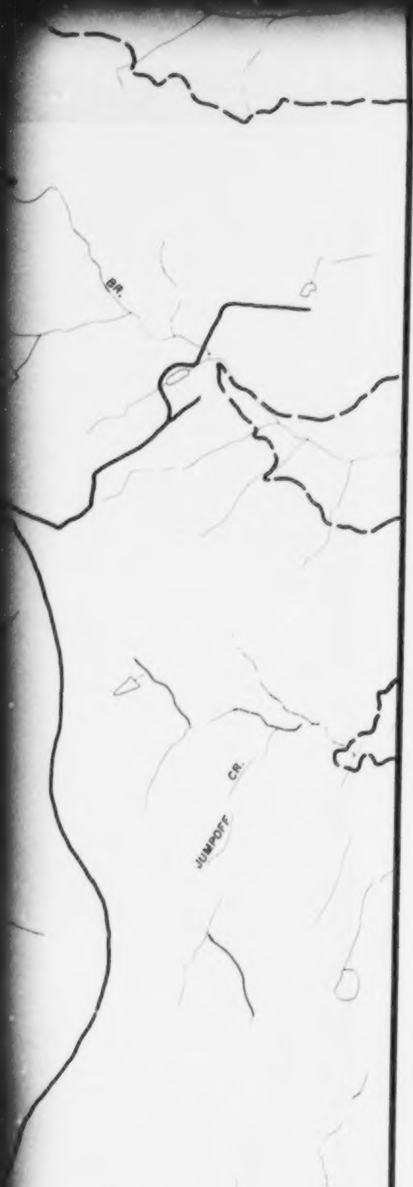

BR.
JUMPOFF CR.
SWEDEN CR.

FIGURE IV-1

SEWANEE, TENNESSEE
201 FACILITIES PLAN

ENVIRONMENTAL IMPACT STATEMENT

ALTERNATIVES CONFIGURATION

1
1/2
0
1
Scale In Miles

U.S. Environmental Protection Agency
Region IV Atlanta, Georgia

Only the cost category can be gauged in a monetary sense of dollars outlaid over the planning period. For the operability, environmental considerations, and implementability evaluations, non-monetary measures of resource costs must be employed in order to rank the alternatives. The most cost-effective alternative is the waste treatment management system which this analysis determines to have the lowest present worth unless non-monetary costs are overriding (Subpart A.6.a, 40 CFR Part 35).

A total resources cost analysis is similarly considered for the scenario of no federal funding availability to the Sewanee Utility District for upgrading and expansion of their wastewater facilities. This does not restrict state, local, or private investment in wastewater management; however, without federal funding to support the proposed structural alternatives being considered, the amount and nature of additional treatment capacity in the Sewanee area in the future would be somewhat different than under any of the five proposed structural alternatives. This "no-action" alternative is the baseline for evaluation of the expected environmental impacts of the various structural alternatives, since it represents essentially how existing conditions would be altered in the future by grown in the absence of federal investment.

PART B. DESCRIPTION OF WASTEWATER MANAGEMENT ALTERNATIVES

The seven treatment/disposal schemes that make up the wastewater management alternatives are listed along with their basic characteristics in Table IV-1. Process schematics of each alternative are illustrated in Figures IV-2 to IV-8.

In the Alternatives Development Technical Reference Document Section 4) of Part B) it was noted that consideration must be given in the development of the alternatives to the reliability of the proposed treatment system. According to EPA design criteria, the process trains of Alternatives 1, 2, and 3 fall under Reliability Class II and the process trains of the land application systems, Alternatives 4, 5, 6, and 7 come under Reliability Class III. Such Reliability classifications stipulate which process units require duplication in order to meet this specified degree of system reliability. A description of how the reliability criteria will affect the proposed treatment processes of each alternative was also provided in the Alternatives Development Technical Reference Document. The descriptions for Alternatives 1,2, and 3 remain unchanged but the descriptions for Alternatives 4, 5, 6, and 7 are as follows:

Alternatives 4 and 6 - Land Treatment (Class III) - Land Treatment (Class III): Utilize existing units an additional primary clarifier will be required but since the clarifier is the only major component in the treatment system it is sized according to the reliability requirements for biological treatment components of Class I. This should compensate for the lack of other treatment units in this unconventional system.

TABLE IV-1

SEWANEE, TENNESSEE
ENVIRONMENTAL IMPACT STATEMENT
DESCRIPTION OF WASTEWATER MANAGEMENT ALTERNATIVES

Alternative	Type Treatment	Treatment Level (1)	Discharge	Process Components (2)
1	Advanced, nitrification Upgrade existing STP	I	Depot Branch	Primary clarifiers Trickling filter (recirculation added) Activated sludge units Secondary clarifiers Aerobic sludge digester
2	Advanced, nitrification; Construct new STP at existing site	I	Depot Branch	Extended aeration units Final clarifiers Aerobic sludge digester
3	Secondary; Upgrade existing STP	II	Elk River	Primary clarifiers Trickling filter (recirculation added) Secondary clarifiers Aerobic sludge digester
4	Land application Upgrade existing STP	B	Spray irrigation at Rutledge Farm Site	Primary clarifiers Aerobic sludge digester Spray irrigation facilities for solid set spray distribution (includes a storage pond)
5	Land application Construct new STP at spray site	B	Spray irrigation at Rutledge Farm Site	Facultative lagoon (also serves as a storage pond) Spray irrigation facilities for solid set spray distribution
6	Land application Upgrade existing STP	B	Spray irrigation at Garnerstown and St. Marys Sites	Primary clarifiers Aerobic sludge digester Spray irrigation facilities for solid set spray distribution (includes a storage pond)
7	Land application Construct new STP at spray site	B	Spray irrigation at Garnerstown and St. Marys Sites	Facultative lagoon (also serves as a storage pond) Spray irrigation facilities for solid set spray distribution

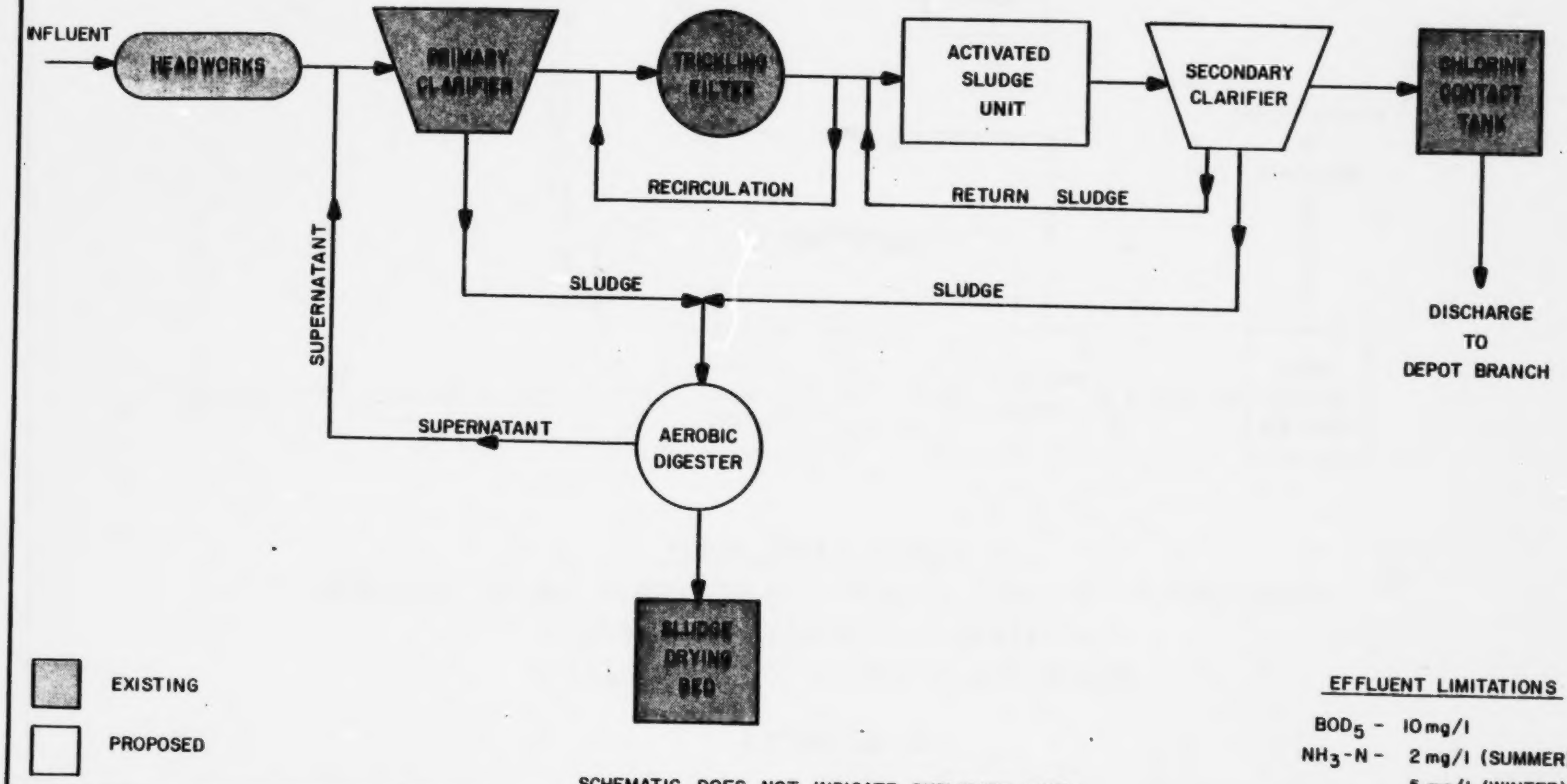
(1) Treatment Levels: I; BOD_5 - 10 mg/1, NH_3-N-2 mg/1 (summer); 5 mg/1 (winter)
II; BOD_5 - 30 mg/1, SS-30 mg/1
B; Fecal Coliforms - less than 1,000 MPN/100 ml

(2) All alternatives include headworks (equalization basin and preliminary treatment facilities), chlorination facilities, and sludge drying beds

Source: GFC&C, Inc.

FIGURE IV - 2

ALTERNATIVE I PROCESS SCHEMATIC
ADVANCED, NITRIFICATION TREATMENT
EXISTING PLANT SITE
TREATMENT LEVEL I


INFLUENT
HEADWORKS
PRIMARY CLARIFIER
TRICKLING FILTER
ACTIVATED SLUDGE UNIT
SECONDARY CLARIFIER
CHLORINE CONTACT TANK
RECIRCULATION
RETURN SLUDGE
SUPERNATANT
SLUDGE
SLUDGE
DISCHARGE TO DEPOT BRANCH
SUPERNATANT
AEROBIC DIGESTER
SLUDGE DRYING BED
EXISTING
PROPOSED

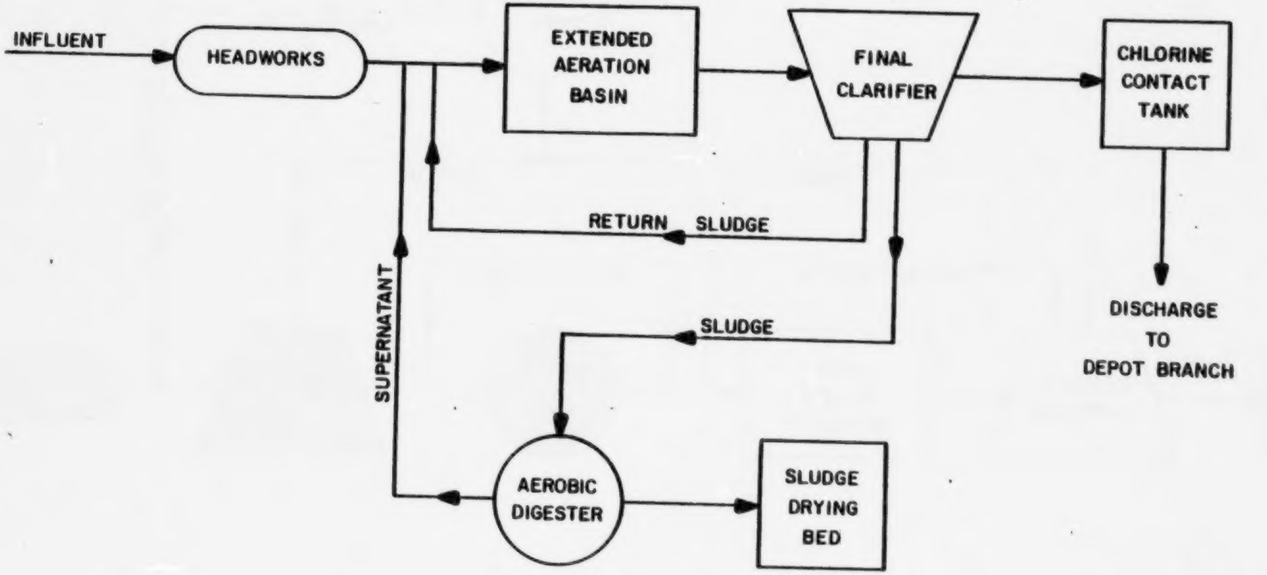
SCHEMATIC DOES NOT INDICATE DUPLICATE UNITS

EFFLUENT LIMITATIONS

BOD_5 - 10 mg/l
NH_3-N - 2 mg/l (SUMMER)
5 mg/l (WINTER)

FIGURE IV - 3

ALTERNATIVE 2 PROCESS SCHEMATIC
ADVANCED, NITRIFICATION TREATMENT
EXISTING PLANT SITE / ABANDONMENT OF EXISTING STRUCTURES
TREATMENT LEVEL I


INFLUENT
HEADWORKS
EXTENDED AERATION BASIN
FINAL CLARIFIER
CHLORINE CONTACT TANK
RETURN SLUDGE
SLUDGE
SUPERNATANT
DISCHARGE TO DEPOT BRANCH
AEROBIC DIGESTER
SLUDGE DRYING BED

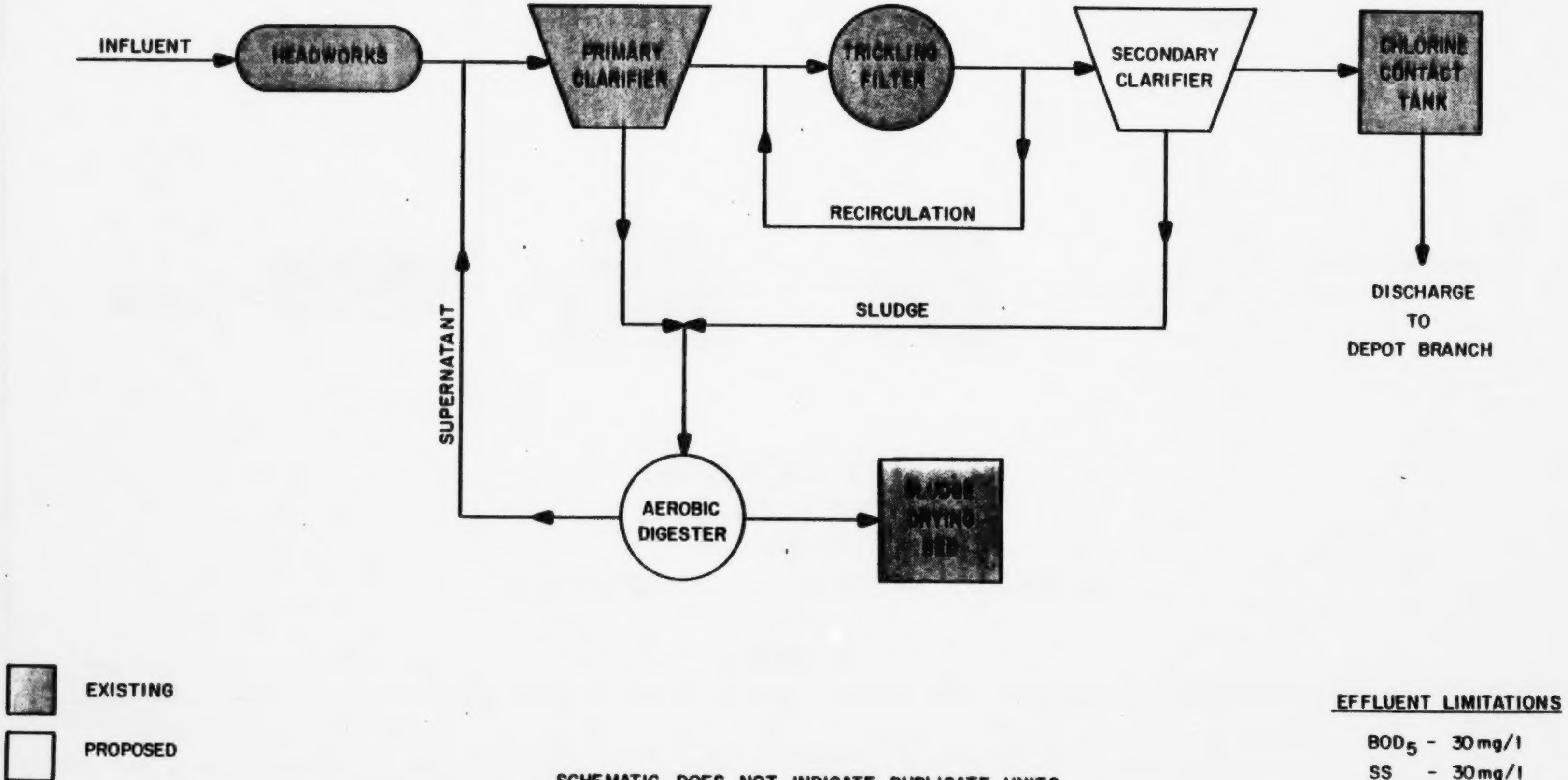
EFFLUENT LIMITATIONS

BOD_5 - 10 mg/l
NH_3-N - 2 mg/l (SUMMER)
5 mg/l (WINTER)

SCHEMATIC DOES NOT INDICATE DUPLICATE UNITS

FIGURE IV - 4

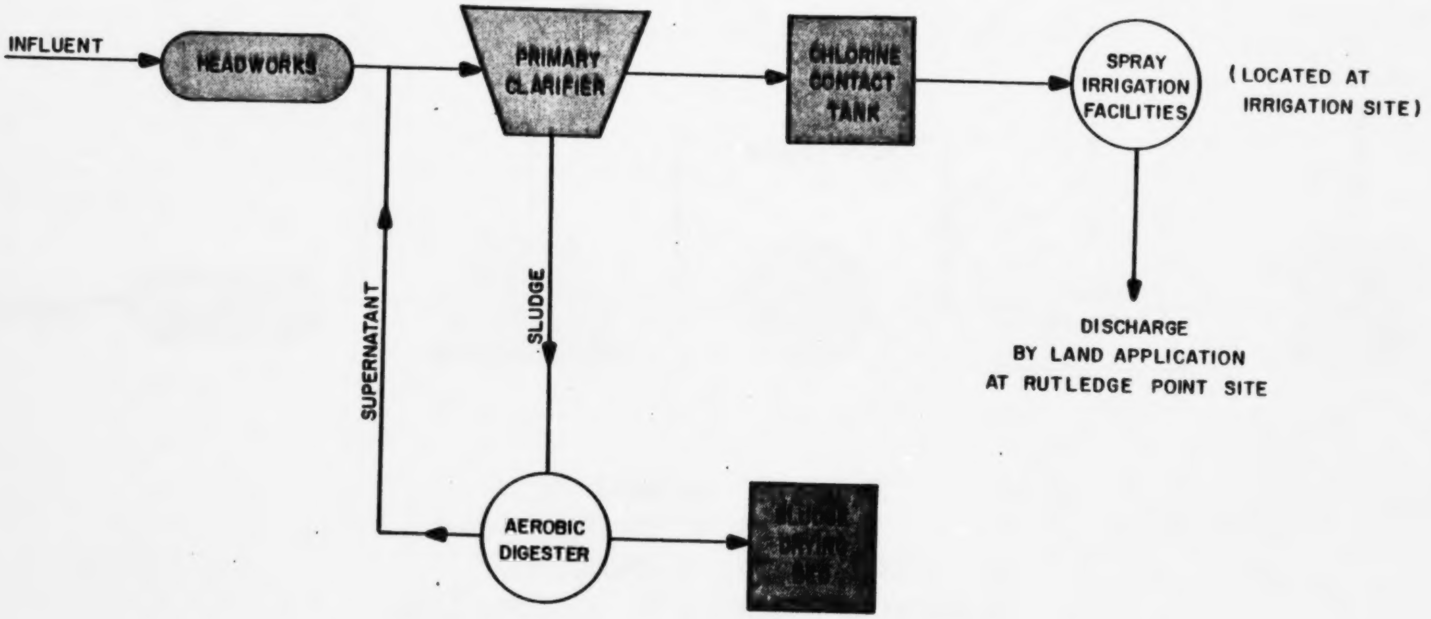
ALTERNATIVE 3 PROCESS SCHEMATIC
SECONDARY TREATMENT
EXISTING PLANT SITE
TREATMENT LEVEL II


INFLUENT
HEADWORKS
PRIMARY CLARIFIER
TRICKLING FILTER
SECONDARY CLARIFIER
CHLORINE CONTACT TANK
RECIRCULATION
SLUDGE
SUPERNATANT
AEROBIC DIGESTER
SLUDGE DRYING BED
DISCHARGE TO DEPOT BRANCH
EXISTING
PROPOSED
EFFLUENT LIMITATIONS
BOD5 - 30mg/l
SS - 30mg/l

SCHEMATIC DOES NOT INDICATE DUPLICATE UNITS

FIGURE IV -5

ALTERNATIVE 4 PROCESS SCHEMATIC
LAND TREATMENT
EXISTING PLANT SITE
TREATMENT LEVEL B


INFLUENT
HEADWORKS
PRIMARY CLARIFIER
CHLORINE CONTACT TANK
SPRAY IRRIGATION FACILITIES
(LOCATED AT IRRIGATION SITE)
SUPERNATANT
SLUDGE
DISCHARGE BY LAND APPLICATION AT RUTLEDGE POINT SITE
AEROBIC DIGESTER
SLUDGE DRYING BEDS

▨ EXISTING

☐ PROPOSED

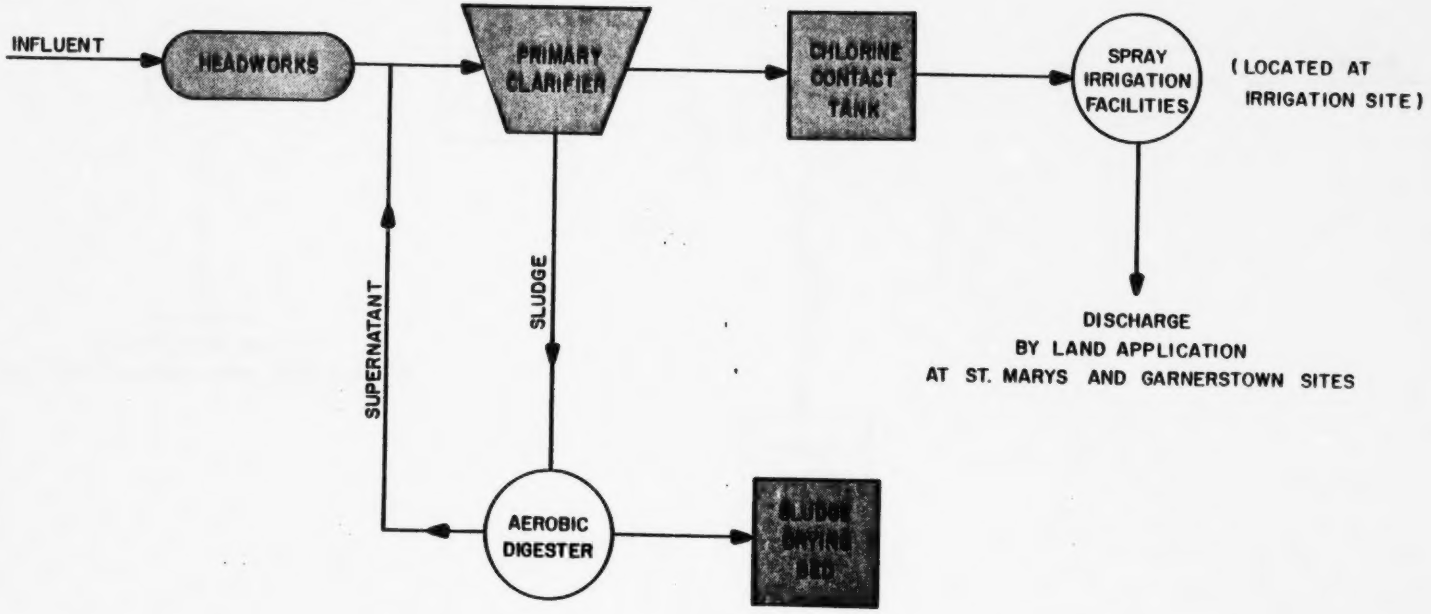
SCHEMATIC DOES NOT INDICATE DUPLICATE UNITS

EFFLUENT LIMITATIONS

FECAL COLIFORMS-
1000 MPN / 100 ml

FIGURE IV - 7

ALTERNATIVE 6 PROCESS SCHEMATIC
LAND TREATMENT
EXISTING PLANT SITE
TREATMENT LEVEL B


INFLUENT
HEADWORKS
PRIMARY CLARIFIER
CHLORINE CONTACT TANK
SPRAY IRRIGATION FACILITIES
(LOCATED AT IRRIGATION SITE)
SLUDGE
SUPERNATANT
AEROBIC DIGESTER
SLUDGE DRYING BED
DISCHARGE
BY LAND APPLICATION
AT ST. MARYS AND GARNERSTOWN SITES

▨ EXISTING

☐ PROPOSED

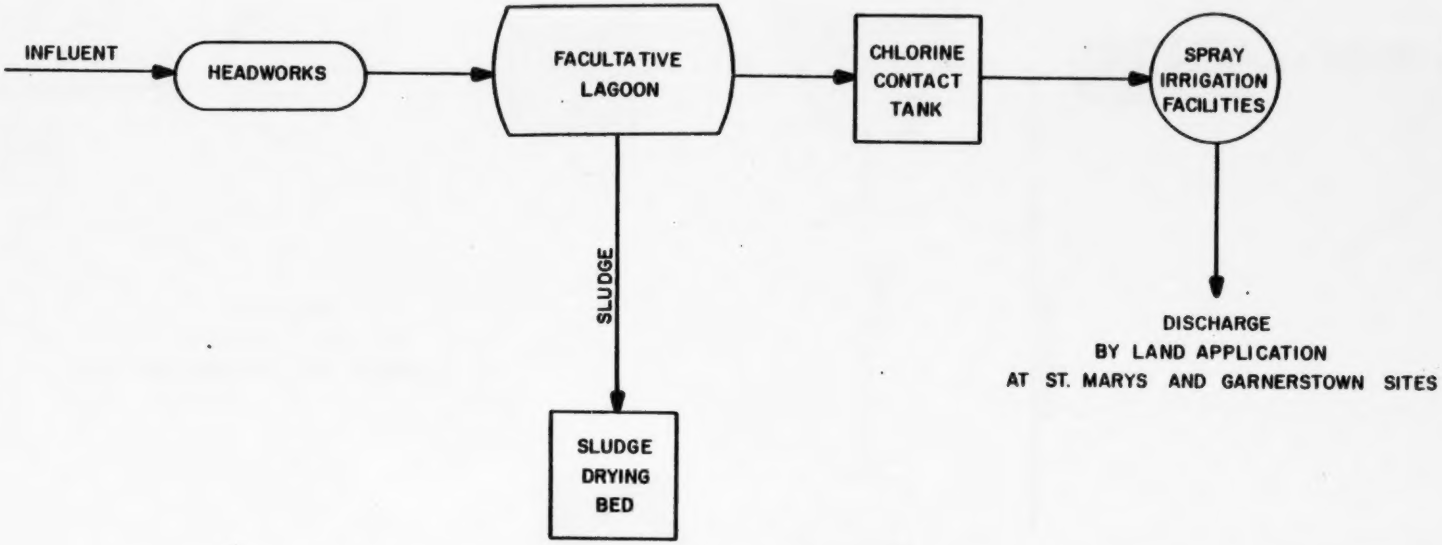
SCHEMATIC DOES NOT INDICATE DUPLICATE UNITS

EFFLUENT LIMITATIONS

FECAL COLIFORMS-
1000 MPN/ 100 ml

FIGURE IV - 8

ALTERNATIVE 7 PROCESS SCHEMATIC
LAND TREATMENT
NEW PLANT SITE
TREATMENT LEVEL B


INFLUENT
HEADWORKS
FACULTATIVE LAGOON
CHLORINE CONTACT TANK
SPRAY IRRIGATION FACILITIES
SLUDGE
SLUDGE DRYING BED
DISCHARGE
BY LAND APPLICATION
AT ST. MARYS AND GARNERSTOWN SITES

EFFLUENT LIMITATIONS

FECAL COLIFORMS-
1000 MPN/100ml

SCHEMATIC DOES NOT INDICATE DUPLICATE UNITS

Alternatives 5 and 7 - Land Treatment (Class III) - Land Treatment (Class III): Abandon Existing Units no duplication necessary for a facultative lagoon but it is suggested in other sources that, based on experience, a lagoon should be divided into several cells with the capability of closing off any cell.

It should be noted that, even though all the other alternatives require the construction of an aerobic digester, the alternatives (5 and 7) using facultative lagoons do not. This is because the sludge accumulated in the lagoons will be digested in the bottom, anaerobic layer of the lagoon itself.

PART C. COST EVALUATION

1. Introduction

There are two general types of analyses that are considered in the cost evaluation: the present worth cost analysis and the local annual cost analysis. The present worth analysis establishes comparative totals over the planning period including the federal share associated with construction grants. This analysis is an EPA requirement in performing the cost-effectiveness evaluation. The local annual cost analysis compares the local share of the cost of constructing, operating and maintaining the wastewater systems on an annual basis. This is a measure of annual revenue requirements and, therefore, of cost to the users.

It is the present worth analysis, under EPA guidelines, which is used as the primary evaluative criteria in terms of cost. The local annual cost analysis is conducted as a secondary cost evaluation, not be be used as the alternatives cost ranking mechanism. The implementation of the proposed alternatives can be better gauged with such information leading to the annual cost to the users. This is further addressed in the Implementability Evaluation, Part F, of this report.

The development of capital construction costs and operation and maintenance (O&M) costs for the proposed wastewater alternatives is found in the following section. With these two cost components assembled for each alternative, both the present worth and local annual costs are calculated to enable ranking of the seven alternatives.

2. Cost Development

Initiation of a cost evaluation for the proposed alternatives first requires compilation of process unit component costs for each alternative. Construction costs and operation and maintenance costs are assembled in Tables IV-2, IV-3, and IV-4.

TABLE IV-2
WASTEWATER MANAGEMENT ALTERNATIVES
SUMMARY OF CONSTRUCTION AND PROJECT COSTS (1)

	Discharge to Depot Branch		Discharge to Elk River	Spray Irrigation			
				Discharge to Rutledge Farm Site		Discharge to Garnerstown & St. Marys Sites	
Component	Exist. Units Alt. 1	New Process Alt. 2	Exist. Units Alt. 3	Exist. Units Alt. 4	Facul. Lag Alt. 5	Exist. Units Alt. 6	Facul. Lag Alt. 7
TREATMENT PLANT							
Equalization Basin	$ 163,200	$ 163,200	$ 163,200	$ 163,200	$ 163,200	$ 163,200	$ 163,200
Preliminary Treatment	62,400	62,400	62,400	62,400	62,400	62,400	62,400
Raw Wastewater Pumping	90,000	90,000	90,000	90,000	-	90,000	-
Primary Clarifiers	85,200	-	85,200	115,000	-	115,000	-
Repair Trickling Filter	76,800	-	76,800	-	-	-	-
New Trickling Filter	-	-	79,200	-	-	-	-
Recirculation Pumping	60,000	-	60,000	-	-	-	-
Activated Sludge	344,400	484,800	-	-	-	-	-
Secondary Clarifiers	92,400	92,400	92,400	-	-	-	-
Aerobic Digestion	214,800	145,200	232,800	167,500	-	167,500	-
Sludge Drying Beds	27,200	34,800	26,400	26,400	34,800	26,400	34,800
Chlorine Contact	39,600	39,600	39,600	45,000	39,600	45,000	39,600
Control Building & Laboratory	120,000	120,000	120,000	120,000	120,000	120,000	120,000
Raze Digester & Building	38,400	38,400	38,400	38,400	-	38,400	-
Pumping to Elk River/Spray Site	-	-	136,800	136,800	136,800	136,800	136,800
Subtotal Treatment Plant	1,424,400	1,270,800	1,303,200	964,700	556,800	964,700	556,800
Interunit Piping (2)	114,000	50,400	104,400	77,200	-	77,200	-
Site Work (3)	213,700	190,600	195,500	144,700	83,500	144,700	83,500
Total Treatment Plant	1,752,100	1,511,800	1,603,100	1,186,600	640,300	1,186,600	640,300
CONVEYANCE							
Force Main to Elk River/ Spray Irrigation Site	-	-	810,000	279,600	279,600	146,300	146,300
LAND APPLICATION							
Spray Irrigation (4)	-	-	-	596,800	788,800	547,400	739,400
Land Cost				475,500	475,500	347,500	347,500
Total Land Application				1,072,300	1,264,300	894,900	1,086,900
TOTAL CONSTRUCTION COST	$1,752,100	$1,511,800	$2,413,100	$2,663,400	$2,184,200	2,227,800	1,873,500
TOTAL PROJECT COST (5)	$2,277,700	$1,965,300	$3,137,000	$3,462,400	$2,839,500	2,896,100	2,435,600

(1) Primary sources of construction costs except as noted in text are: Small Community Wastewater Treatment Facilities - Biological Treatment Systems (Treatment Plant); EIS consultant (Conveyance); and Costs of Land Treatment Systems (Land Application). Based upon 1978 price levels.

(2) Assumed to be 8% of treatment plant subtotal except for alternative 2 which is taken as 4% of subtotal due to process unit consolidation.

(3) Assumed to be 15% of treatment plant construction cost subtotal.

(4) This table utilizes the costs for an application rate of 3 inches per week. Refer to Table IV-4 for the breakdown of spray/site operations costs for all application rates.

(5) Project cost includes construction cost plus an allowance of 30% to cover engineering, administrative, legal, financial and contingency costs.

Source: GFC&C, Inc.

TABLE IV-3

WASTEWATER MANAGEMENT ALTERNATIVES
SUMMARY OF ANNUAL OPERATION AND MAINTENANCE COSTS (1)

				Spray Irrigation			
	Discharge to Depot Branch		Discharge to Elk River	Discharge to Rutledge Farm Site		Discharge to Garnerstown & St. Marys Sites	
Component	Exist. Units Alt. 1	New Process Alt. 2	Exist. Units Alt. 3	Exist. Units Alt. 4	Facul. Lag Alt. 5	Exist. Units Alt. 6	Facul. Lag Alt. 7
Flow Equalization w/Aeration	$4,428	$4,428	$4,428	$4,428	$4,428	$4,428	$4,428
Preliminary Treatment	2,934	2,934	2,934	2,934	2,934	2,934	2,934
Wastewater Pumping	1,530	1,530	1,530	1,530	-	1,530	-
Primary Clarifier	5,424	-	5,424	6,437	-	6,437	-
Sludge Pumping (primary)	2,556	-	2,556	2,556	-	2,556	-
Trickling Filtration	1,938	-	3,372	-	-	-	-
Activated Sludge	2,484	-	-	-	-	-	-
Extended Aeration	-	6,366	-	-	-	-	-
Recirculation Pumping	2,400	966	1,404	1,404	-	-	-
Sludge Pumping (return and/or secondary)	3,024	3,306	3,024	-	-	-	-
Secondary Clarifier	4,206	4,206	4,206	-	-	-	-
Digestion	2,460	1,998	2,460	2,460	-	2,460	-
Chlorination	2,940	2,940	2,940	3,810	2,940	3,810	2,940
Chlorine Supply	1,656	1,656	1,656	3,140	1,656	3,140	1,656
Laboratory Analysis	4,368	3,618	4,368	4,368	3,618	4,368	3,618
Administration	3,372	3,372	3,372	3,372	3,372	3,372	3,372
Additional Pumping	-	-	4,380	3,680	4,380	3,680	3,680
Power Requirements	22,464	32,448	6,240	6,240	6,240	6,240	6,240
Spray Site Operations (2)	-	-	-	15,900	24,840	14,120	23,060
TOTAL ANNUAL YEAR O&M COST	$68,300	$69,800	$54,400	$62,300	$54,500	$59,100	$51,900

(1) Source: Small Community Wastewater Treatment Facilities-Biological Treatment Systems and Costs of Land Treatment Systems.

(2) This table utilizes the costs for an application rate of 3 inches per week. Refer to Table IV-4 for the breakdown of spray/site operations costs for all applications rates.
Source: GFCC, Inc.

TABLE IV-4

WASTEWATER MANAGEMENT ALTERNATIVES
SPRAY IRRIGATION CONSTRUCTION AND OPERATING & MAINTENANCE COSTS (1)

Component	Capital Construction Costs Application Rate, inch per week				Year 2000 - Operating & Maintenance Cost Application Rate, inch per week			
	1.0	2.0	3.0	4.0	1.0	2.0	3.0	4.0
Storage Pond (2)	$126,600	$126,600	$126,600	$126,600	$ 710	$ 710	$ 710	$ 710
Facultative Lagoon (3) (provides storage)	301,000	301,000	301,000	301,000	9,650	9,650	9,650	9,650
Field Preparation (2) (storage pond only)	12,000	12,000	12,000	12,000	-	-	-	-
Field Preparation (3) (facultative lagoon)	29,600	29,600	29,600	29,600	-	-	-	-
Distribution Pumping	182,400	182,400	182,400	182,400	4,080	4,080	4,080	4,080
Distribution, Solid Set Spray	285,000	150,400	114,700	87,100	13,470	8,320	6,250	5,350
Service Roads (4)	92,200	92,200	92,200	92,200	3,900	3,900	3,900	3,900
Service Roads (5)	60,900	60,900	60,900	60,900	2,310	2,310	2,310	2,310
Monitoring Wells	3,000	3,000	3,000	3,000	360	360	360	360
Fencing (4)	65,900	65,900	65,900	65,900	600	600	600	600
Fencing (5)	47,800	47,800	47,800	47,800	410	410	410	410
Total - Alternative 4	$ 767,100	$ 632,500	$ 596,800	$ 569,200	$ 23,120	$ 17,970	$ 15,900	$ 15,000
Total - Alternative 5	$ 959,100	$ 824,500	$ 788,800	$ 761,200	$ 32,060	$ 26,910	$ 24,840	$ 23,940
Total - Alternative 6	$ 717,700	$ 583,100	$ 547,400	$ 519,800	$ 21,340	$ 16,190	$ 14,120	$ 13,220
Total - Alternative 7	$ 909,700	$ 775,100	$ 739,400	$ 711,800	$ 30,280	$ 25,130	$ 23,060	$ 22,160

(1) Based on specified application rate (inches per week) and 1981 price levels. Source: Costs of Land Treatment Systems.
(2) Applies to Alternatives 4 and 6.
(3) Facultative lagoon includes volume for storage, applies to Alternatives 5 and 7.
(4) Based on total acreage of Rutledge Farm Site, applies to Alternatives 4 and 5.
(5) Based on total acreage of the two sites, St. Marys and Garnerstown, applies to Alternatives 6 and 7.

Source: GFC&C , Inc.

Table IV-2 segregates the component construction costs into three general categories: treatment plant costs, conveyance costs, and land application costs. These are all construction costs adjusted to reflect local area, last quarter 1978 price and labor rate levels. For the purposes of the cost analysis, construction of the wastewater facilities is assumed to begin in 1983, resulting in a 17-year planning period which extends to the year 2000.

Based upon experience with the construction of wastewater treatment facilities; the cost of engineering design and inspection, legal and administrative fees, financing costs, and general contingencies will add an estimated 30 percent to the overall cost of the wastewater program. The construction cost plus these additional related costs are together commonly referred to as the project cost. Only the final line of Table IV-2 lists a project cost, all other costs shown in this table are strictly construction costs.

The operating and maintenance costs shown in Table IV-3 are based upon 1978 price and labor rate levels for the Sewanee area. These costs are calculated for the design wastewater flow in the year 2000. Operation and maintenance (O&M) costs for the first year of operation (1983) are based upon the premise that approximately one-fourth of the O&M costs are flow related.

Component construction and O&M costs have been gathered primarily from two sources. Cost curves contained in the 1978 EPA Small Small Community Wastewater Treatment Facilities - Biological Treatment Systems publication were utilized to estimate the costs for the majority of the new treatment process units. Costs associated with the land application components are based on cost curves presented in the 1979 Cost of Land Treatment Systems publication. As previously publication. As previously mentioned, these costs were adjusted to reflect 1978 South-central Tennessee price levels. These costs were independently estimated by the EIS consultant's engineering design specialists for verification of the cost estimates.

Construction costs for those process units which are to be rehabilitated under Alternatives 1, 3, 4, 5, and 6 were estimated by the contract consultant's wastewater facilities design specialist. The cost of razing the existing digester and utility building was obtained from the 201 Facilities Plan. Table IV-4 lists the construction and operating and maintenance costs of the spray irrigation components for the land application Alternatives 4, 5, 6, and 7. This table illustrates the variance of costs with effluent application rates of 1.0, 2.0, 3.0, and 4.0 inches per week. For comparison with other treatment/disposal alternatives, the application rate of 3 inches per week, as recommended by Dr. Sopper, is used in the present worth and local annual cost analyses.

3. Present Worth Cost Analysis

As previously noted, the alternative wastewater treatment systems must be compared on the basis of their relative present worth costs in accordance with EPA cost-effectiveness analysis guidelines (40 CFR 35, Subpart A). The present worth analysis establishes a total cost value of the capital expenditures and operating costs of each alternative over the duration of the planning period. The present worth costs for the facilities evaluated in this report are developed for a 17-year planning period beginning in the year 1983, at a discount rate of 7.125 percent. This discount rate is the updated discount rate as stipulated by EPA which was adopted from guidelines of the Water Resources Council. In accordance with the EPA guidelines, allowances are made for salvage values at the end of the planning period. All construction is assumed to be performed during 1982-1983, with no planned phasing of construction due to the relatively small size of the project and limited growth over the planning period.

The wastewater treatment, conveyance, and spray irrigation project costs and operation & maintenance costs were analyzed in accordance with these present worth guidelines. The total 1983 present worth costs of each alternative are presented in Table IV-5. These costs are the estimated project costs associated with a wastewater management alternative plus the present worth of annual O&M costs during the planning period, minus the present worth salvage values of the particular treatment/disposal systems at the end of the planning period (year 2000).

Table IV-6 demonstrates the variation of the total present worth costs with the effluent application rate for the land application Alternatives 4, 5, 6, and 7. With a decreased application rate due to possible soil limitations, the alternative present worth costs increase. This is a result of increased equipment requirements and operation and maintenance costs associated with the resulting expanded spray irrigation field area. As noted before, an application rate of 3 inches per week is used for the cost evaluation.

On a total net present worth basis, Alternative 2, the extended aeration treatment scheme, appears to be the most attractive. This is followed by the land application Alternative 7 with a 5 percent higher total net present worth than Alternative 2.

As of October 1, 1978, under the EPA Grants Regulations (40 CFR 35, Subpart A.7.a) "innovative" and "alternative" wastewater schemes may be grant eligible provided that they are not more than 115 percent of the present worth cost of the most cost-effective "conventional" scheme. The land application Alternatives 4, 5, 6, and 7 are classified as innovative technology, therefore, a cost adjustment factor of 115 percent is incorporated into the conventional Alternative 1, 2, and 3 for comparison purposes (refer to Table IV-5, last row). This shows the land application Alternative 7 to be the most desirable with Alternative 2 now 10 percent higher in present worth costs.

4. Local Annual Cost Analysis

The local annual cost analysis differs from the present worth analysis in several ways. Local annual costs reflect more closely the

TABLE IV-5

WASTEWATER MANAGEMENT ALTERNATIVES
PRESENT WORTH ANALYSIS (1)

				Spray Irrigation			
	Discharge to Depot Branch		Discharge to Elk River	Discharge to Rutledge Farm Site		Discharge to Garnerstown & St. Marys Sites	
Capital Cost	Exist. Units Alt. 1	New Process Alt. 2	Exist. Units Alt. 3	Exist. Units Alt. 4	Facul. Lag Alt. 5	Exist. Units Alt. 6	Facul. Lag Alt. 7
Treatment Plant							
1983 Project Cost	$2,277,700	$ 1,965,300	$2,084,000	$1,542,600	$ 832,400	$1,542,600	$ 832,400
2000 Salvage Value(2)	842,700	727,200	771,100	570,800	308,000	570,800	308,000
P.W. Salvage Value	261,600	225,700	239,300	177,200	114,000	177,200	114,000
Net Present Worth	2,016,100	1,739,600	1,844,700	1,365,400	718,400	1,365,400	718,400
Conveyance							
1983 Project Cost	-	-	1,058,000	363,500	363,500	190,200	190,200
2000 Salvage Value(2)	-	-	695,000	239,900	239,900	125,500	125,500
P.W. Salvage Value	-	-	215,700	74,500	74,500	39,000	39,000
Net Present Worth	-	-	837,300	289,000	289,000	151,200	151,200
Land Application							
1983 Project Cost	-	-	-	1,394,000	1,643,600	1,163,400	1,413,000
2000 Salvage Value(2)	-	-	-	1,254,600	1,329,400	745,300	820,200
P.W. Salvage Value	-	-	-	389,400	412,700	231,300	254,600
Net Present Worth	-	-	-	1,004,600	1,230,900	932,100	1,158,400
TOTAL NET P.W. CAPITAL COST	$2,016,100	$1,739,600	$2,682,000	$2,659,000	$2,238,300	$2,448,700	$2,028,000
Operating Cost							
2000 Operating Cost	68,300	69,800	54,400	62,300	54,500	59,100	51,900
1983 Operating Cost (3)	66,300	67,700	52,800	60,400	52,900	57,300	50,300
Operating Cost P.W.	649,500	663,400	517,200	592,000	518,200	561,600	493,000
TOTAL PRESENT WORTH	2,665,600	2,403,000	3,199,200	3,251,000	2,756,500	3,010,300	2,521,000
TOTAL PRESENT WORTH ADJUSTED FOR 115 PERCENT SPRAY IRRIGATION ALLOWANCE (4)	3,065,400	2,763,500	3,679,100	3,251,000	2,756,500	3,010,300	2,521,000

(1) Present worth analysis is based on 1981 price levels, 17-year planning period and a 7.125% discount rate
(2) Year 2000 salvage values as percentages of initial construction costs are: conveyance = 66%; treatment plant = 37%; land application = 30% + land s.v
(3) Ratio of 1983/2000 O&M Costs is 0.97 assuming that one forth of O&M costs are flow related
(4) In accordance with EPA Program Requirements Memorandum (PRM) 79-3, 15% adjustment of least cost alternative for comparison with innovative/alternative technolopy alternatives.

Source: GFCC, Inc.

TABLE IV-6
WASTEWATER MANAGEMENT ALTERNATIVES
VARIATION OF PRESENT WORTH COST WITH EFFLUENT APPLICATION RATE

Application Rate	Alt. 4	Alt. 5	Alt. 6	Alt. 7
4 in/week	$3,218,400	$2,724,000	$2,977,700	$2,488,400
3 in/week	3,251,000	2,756,500	3,010,300	2,521,000
2 in/week	3,293,100	2,798,600	3,052,300	2,563,100
1 in/week	3,451,800	2,957,300	3,217,000	2,721,800

Source: GFC&C, Inc.

relative impacts of the alternatives on the system owner, the Sewanee Utility District, and its users. These costs are computed accounting for the federal construction grant for the new wastewater facilities. The remaining costs of construction and other related project costs not covered by the federal grant are amortized as an assumed 30-year debt at the federal 7.125 percent interest rate. This debt service together with past debt service obligations and estimated operation and maintenance costs of the facilities for one year are used in determining the local annual cost for each alternative. As stated previously, this cost analysis is intended to help evaluate the potential for implementation of the alternatives in light of the projected "user cost".

For the proposed alternatives, the new project total local annual costs are displayed in Table IV-7. It should be noted that the local annual cost analysis gives the four spray irrigation alternatives a distinct advantage due to the fact that they would be 85 percent federally funded for the eligible project cost, whereas the other conventional treatment/stream discharge alternatives are 75 percent federally funded.

Table IV-8 reflects the local annual cost for the new proposed project plus existing annual costs presently being incurred which will continue as an expense. These existing costs are: collection system operation and maintenance costs, other administrative, billing, and legal costs; and the outstanding debt on the 1974 sewer revenue bond issue.

From the costs in both tables, Alternative 7 is the most desirable by having the lowest total local annual costs and the lowest average residential annual billing fee.

In summarizing the present worth cost analyses and the local annual cost analysis, the proposed wastewater treatment/disposal schemes are ranked as follows:

Adjusted Present Worth Cost
(primary criteria)
Alternative 7 - $2,521,000
Alternative 5 - $2,756,500
Alternative 2 - $2,763,500
Alternative 6 - $3,010,300
Alternative 1 - $3,065,400
Alternative 4 - $3,251,000
Alternative 3 - $3,679,100

Local Annual Cost
(secondary consideration)
Alternative 7 - $104,600
Alternative 5 - $114,900
Alternative 6 - $120,400
Alternative 2 - $127,400
Alternative 4 - $131,300
Alternative 1 - $134,300
Alternative 3 - $143,600

TABLE IV-7

WASTEWATER MANAGEMENT ALTERNATIVES
LOCAL ANNUAL COSTS (1983)
CONSTRUCTION OF NEW WASTEWATER FACILITIES

				Spray Irrigation			
	Discharge to Depot Branch		Discharge to Elk River	Discharge to Rutledge Farm Site		Discharge to Garnerstown & St. Marys Sites	
Component	Exist. Units Alt. 1	New Process Alt. 2	Exist. Units Alt. 3	Exist. Units Alt. 4	Facul. Lag Alt. 5	Exist. Units Alt. 6	Facul. Lag Alt. 7
Project Cost	$2,277,700	$1,965,300	$3,137,000	$3,300,100	$2,839,500	$2,896,100	$2,435,600
Eligible Project Cost(1)	2,049,900	1,768,800	2,823,300	2,970,100	2,555,600	2,606,500	2,192,000
Federal Grant(2)	1,537,400	1,326,600	2,117,500	2,524,600	2,172,300	2,215,500	1,863,200
Local Share	740,300	638,700	1,019,500	775,500	667,200	680,600	572,400
Annual Debt Service(3)	60,400	52,100	83,200	63,300	54,400	55,500	46,700
Infiltration & Inflow(4) Corrective Work	7,600	7,600	7,600	7,600	7,600	7,600	7,600
Total Annual Debt Service	68,000	59,700	90,800	70,900	62,000	63,100	54,300
1983 O&M Cost	66,300	67,700	52,800	60,400	52,100	57,300	50,300
Total Annual Cost (New Project)	$ 134,300	$ 127,400	$ 143,600	$ 131,300	$ 114,900	$ 120,400	$ 104,600

(1) Eligible project cost is assumed to be 90% of the project cost.

(2) Federal grant is 75% of eligible project cost for alternatives 1, 2, and 3, these being the conventional treatment and discharge alternatives. A federal grant of 85% of eligible project cost is applied to alternatives 4, 5, 6, and 7, these being considered innovative because of land application. EPA's Cost - Effectiveness Guidelines, Subpart E (43 FR 44099) outline these grant percentages.

(3) Annual Debt Service is based upon a 30-year bond issue at 7.125% for local borrowing.

(4) The Sewanee Utility District has borrowed $117,000 at 5% over 30 years from the State of Tennessee to finance their infiltration & inflow corrective work.

Source: GFC&C, Inc.

TABLE IV-8

WASTEWATER MANAGEMENT ALTERNATIVES
LOCAL ANNUAL COSTS (1983)
INDEBTEDNESS-PAST AND PROPOSED WASTEWATER PROJECTS

	Discharge to Depot Branch		Discharge to Elk River	Spray Irrigation			
				Discharge to Rutledge Farm Site		Discharge to Garnerstown & St. Marys Sites	
	Exist. Units Alt. 1	New Process Alt. 2	Exist. Units Alt. 3	Exist. Units Alt. 4	Facul. Lag Alt. 5	Exist. Units Alt. 6	Facul. Lag Alt. 7
Total Annual Cost for Proposed Project(1)	$134,300	$127,400	$143,600	$131,300	$114,900	$120,400	$104,600
Collection System O&M (1983)	4,400	4,400	4,400	4,400	4,400	4,400	4,400
Other Administrative Billing, & Legal Costs(2)	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Water & Sewer Revenue Bond-1974	25,200	25,200	25,200	25,200	25,200	25,200	25,200
1983 Total Annual Local Cost for Wastewater Service	175,900	169,000	185,200	172,900	156,500	162,000	146,200
Average Cost per 1000 Gallons of Billable Water Consumption(3)	$ 2.82	$ 2.71	$ 2.97	$ 2.77	$ 2.51	$ 2.59	$ 2.34
Estimated User Cost (4)							
Monthly:	14.20	13.60	14.90	13.90	12.60	13.00	11.80
Annually:	170.00	163.00	179.00	167.00	151.00	156.00	141.00

(1) See Table IV-6
(2) Assumed allowance based upon EIS consultant's experience
(3) Total billable usage: 61 gpcd x 2805 (service population 1983) x 365 days = 62,453,000 gal/year
(4) Average residential customer: 61 gpcd x 2.7 people customer = 165 gal/customer/day
(This assume a flat rate giving no consideration to graduated rate structure)

Source: GFC&C, Inc.

PART D. OPERABILITY EVALUATION

Systems operability provides a measure of the ability of a wastewater management system to continuously provide the service for which it is designed. The evaluation of operability of the systems should include the assessment of the following three factors:

- reliability of treatment
- flexibility of operations
- maintainability of facilities

Evaluation of reliability considers the ability of the treatment process and spray irrigation facilities to maintain the intended treatment levels. Operational flexibility is a measure of the ability of treatment components to adapt to changes in wastewater characteristics and to comply with changes in water quality goals. Maintainability considerations include the complexity of equipment frequency of maintenance down time, and efficiency of providing required maintenance.

In order to provide a comparative operability ranking of the eight wastewater management alternatives, a numerical rating system is developed which combines ratings for each of the above factors into a total operability score. The rating system provides for a maximum possible operability score of 100 points. Flexibility, reliability and maintainability are weighted at thirty (30), forty (40) and thirty (30) points respectively, thus indicating reliability to be the most significant factor. For any given alternative, each operability factor is rated on a scale of 1 to 10, ten (10) being excellent and one (1) being poor. This rating is multiplied by the weighting proportion to determine the score. For example, a reliability rating of 6 translates to a score of 24.

$$\left(\frac{6}{10} = \frac{24}{40}\right)$$

The basic assumptions used in determining the operability factor ratings for the alternatives are as follows:

- Facilities with lower treatment levels are more reliable and easier to maintain than those with higher treatment levels.
- Spray irrigation of effluent is less flexible and more difficult to maintain than outfall discharge to surface waters. The reliability of land application via spray irrigation is very high and is considered in this study to be better than "conventional" surface discharge.

- Newly constructed facilities are more reliable and flexible than older facilities.

- The more conveyance required by a system the less maintainable it becomes.

- Activated sludge and extended aeration units are more reliable and less maintainable than trickling filters, facultative lagoons, and primary sedimentation units. The flexibility of all these treatment processes varies and is rated with activated sludge units the most flexible followed by, in descending order, extended aeration units, trickling filters, facultative lagoon and primary sedimentation units.

Based on these assumptions, each alternative was assigned points according to five characteristics; level of treatment, type of discharge, age of facility, amount of effluent conveyance, and type of major treatment unit. Table IV-9 illustrates the breakdown of points within each characteristic category and Table IV-10 illustrates how these points are assigned to the various alternatives for determining the alternatives' operability rankings.

The final results of the operability evaluation are presented in Table IV-11. The most desirable alternative from this evaluation is shown to be Alternative 2 -- Construction of new STP with activated sludge treatment units and surface discharge to Depot Branch. A close second is Alternative 7 -- Construction of new STP with a facultative lagoon and land application via spray irrigation at the St. Marys and Garnerstown sites. It should be noted that the overall operability ranking is a relative desirability based upon operational ease and that there are no serious operational problems projected for any of the proposed alternatives.

PART E. ENVIRONMENTAL EVALUATION

1. Introduction

In order to incorporate an environmental impacts evaluation into a cost effectiveness analysis or to compare relative impacts of one wastewater management alternative with another, it is necessary to quantify or assign a numerical value to this subjective evaluation. This section deals with the development of numerical environmental impacts ratings for both the natural and man-made environment and includes a description of the evaluation methodology, a numerical ranking of the eight wastewater management alternatives (includes the no-action alternative) with respect to natural and man-made environmental impacts, and a discussion of the impacts for each of the alternatives.

TABLE IV-9

WASTEWATER MANAGEMENT ALTERNATIVES
OPERABILITY EVALUATION
ALTERNATIVE CHARACTERISTICS POINT ASSIGNMENT

Characteristics	Reliability		Flexibility		Maintainability	
	Breakdown	Possible High	Breakdown	Possible High	Breakdown	Possible High
1. Level of Treatment		3		---		3
Level I	1		---		1	
Level II	2		---		2	
Level B	3		---		3	
2. Type of Discharge		2		3		2
Spray Irrigation	2		1		1	
Surface Discharge	1		3		2	
3. Age of Facility		3		3		---
New	3		3		---	
Old	1		1		---	
4. Amount of Effluent Conveyance		---		---		3
Negligible	---		---		3	
Moderate	---		---		2	
Large	---		---		1	
5. Type of Major Treatment Unit						
Activated Sludge	2	2	4	4	1	2
Extended Aeration	2		3		1	
Trickling Filter	1		2		2	
Facultative Lagoon	1		1		2	
Primary Sedimentation	1		1		2	
Total		10		10		10

TABLE IV-10

WASTEWATER MANAGEMENT ALTERNATIVES
OPERABILITY EVALUATION
ALTERNATIVE POINT ASSIGNMENT

Alternative	Reliability	Flexibility	Maintainability
Alternative 1			
1. Treatment Level I	1	-	1
2. Surface Discharge	1	3	2
3. Old	1	1	-
4. Negligible	-	-	3
5. Activated Sludge	2	4	1
Total	5	8	7
Alternative 2			
1. Treatment Level I	1	-	1
2. Surface Discharge	1	3	2
3. New	3	3	-
4. Negligible	-	-	3
5. Extended Aeration	2	3	1
Total	7	9	7
Alternative 3			
1. Treatment Level II	2	-	2
2. Surface Discharge	1	3	2
3. Old	1	1	-
4. Large	-	-	1
5. Trickling Filters	1	2	2
Total	5	6	7
Alternative 4			
1. Treatment Level B	3	-	3
2. Spray Irrigation	2	1	1
3. Old	1	1	-
4. Large	-	-	1
5. Primary Sedimentation	1	1	2
Total	7	3	7
Alternative 5			
1. Treatment Level B	3	-	3
2. Spray Irrigation	2	1	1
3. New	3	3	-
4. Large	-	-	1
5. Facultative Lagoon	1	1	2
Total	9	5	7
Alternative 6			
1. Treatment Level B	3	-	3
2. Spray Irrigation	2	1	1
3. Old	1	1	-
4. Moderate	-	-	2
5. Primary Sedimentation	1	1	2
Total	7	3	8

TABLE IV-10 (Cont'd.)

Alternative	Reliability	Flexibility	Maintainability
Alternative 7			
1. Treatment Level B	3	-	3
2. Spray Irrigation	2	1	1
3. New	3	3	-
4. Moderate	-	-	2
5. Facultative Lagoon	1	1	2
Total	9	5	8

TABLE IV-11

WASTEWATER MANAGEMENT ALTERNATIVES
OPERABILITY EVALUATION RANKING

Alternative	Reliability	Flexibility	Maintainability	Overall Operability	Ranking
1 - Upgrade existing STP. Discharge to Depot Branch	20	24	21	65	4
2 - Construct new STP. Discharge to Depot Branch	28	27	21	76	1
3 - Upgrade existing STP. Discharge to Elk River	20	18	21	59	6
4 - Upgrade existing STP. Spray irrigation at Rutledge Point site	28	12	21	61	5
5 - Construct new STP. Spray irrigation at Rutledge Point site	36	15	21	72	3
6 - Upgrade existing STP. Spray irrigation at St. Marys and Garnerstown sites	28	9	24	61	5
7 - Construct new STP. Spray irrigation at St. Marys and Garnerstown sites	36	15	24	75	2

2. Evaluation Methodology

A parameter-checklist evaluation methodology was used for the evaluation of impacts to the natural environment for the eight wastewater management alternatives. This methodology presented a specific list of environmental parameters to be investigated for possible impacts but did not require the establishment of direct cause-effect links to project activities. The list of parameters to be investigated was based on the Environmental Inventory prepared for the project, with special emphasis on those resources that had been identified as sensitive.

A scaling-weighting technique was the mechanism utilized to evaluate the potential impacts to the environment for each parameter. Scaling factors were used to estimate the relative magnitude of impacts while weighting factors were used to estimate the relative importance of impacts. Weighting (importance) factors were assigned to each environmental parameter and were constant for all alternatives. Scaling factors varied according to the magnitude of the impact for each alternative.

Factors were assigned to the parameters by an interdisciplinary team of biologists, planners and engineers. Weights and scales ranged from no importance or impact to a highly significant level of importance or impact according to the following numerical scheme:

0 = no importance/impact
1 = slight importance/impact
2 = moderate importance/impact
3 = significant importance/impact
4 = highly significant importance/impact

Impact scaling factors may be either beneficial (+) or adverse (-). The score for an environmental parameter wastewater management alternative combination is the product of the weight and the scale:

$$(\text{Score})_{P-A} = (\text{Weight})_{P} \times (\text{Rate})_{P-A}$$

The score for any given parameter-alternative combination can range from a (-) 16 for a highly significant adverse impact on a parameter with a highly significant importance to a (+) 16 for a highly significant beneficial impact on a similar parameter. The summation of the parameter-alternative scores for an individual alternative yields a cumulative comparative score for that alternative.

The environmental evaluation of alternatives has been subdivided into two components: the natural environment and the man-made environment. Subtotal scores are reported for these two categories and are then combined for the overall environmental evaluation.

3. Parameters and Weights

Evaluation parameters were selected to coincide with the environmental inventory and to emphasize sensitive resources. The conformity with the inventory format insures the inclusion of all significant issues and facilitates the direct comparison of the inventory and evaluation documents. The emphasis on sensitive resources is accomplished through the inclusion of the "Sensitive Areas" parameter and the assignment of weights.

Weights were assigned to reflect the relative importance of the parameters in the study area. The weighting process was executed by an interdisciplinary team. Each team member had been involved in the previous project activities and had an in-depth understanding of the issues and environmental conditions within the study area. Each parameter-weight combination is described below as to its content and significance.

Natural Environment - Parameters & Weights

Climate: Major impacts to climate are not generally associated with wastewater treatment alternatives. Micro-climate changes can be associated with spray field sites, vegetation removal or increases in impervious surfaces (streets, parking lots, houses). Impacts to climate for the Sewanee alternatives are primarily associated with changes in humidity around spray field sites. Since climate impacts are a relatively minor component, a weight of "1" was assigned to the parameter.

Air Quality: Long term direct impacts to air quality can be caused by increased vehicular traffic associated with plant maintenance and operation and by sludge incineration among other factors. In addition, short term direct impacts are associated with the construction of new facilities. Long term indirect impacts to air quality can be caused by increased vehicular traffic associated with increased secondary growth of the local population. Air quality impacts were assessed to be of relatively minor importance and were assigned a weight of "1".

Odor: The environmental inventory indicated that there are currently several areas with moderate odor problems. These problems are associated with the current treatment facility and with some septic systems. Since problems do exist in the area, odor was assigned a weight of "2" or moderate.

Noise: Noise impacts are generally direct in nature. Short term direct impacts are associated with facility and pipeline construction. Long term direct impacts can be caused by facility operation. Noise impacts were assessed to be of slight importance for the project alternatives and were assigned the weight of "1".

Topography: Major impacts to the topography can be associated with mining projects but are usually minor for waste treatment projects. Minor topographic impacts may be associated with facility construction. A weight of "1" was therefore assigned to this parameter.

Geology: As for topography, geologic impacts for waste treatment projects are usually minor. A weight of "1" was assigned to the parameter.

Soils: Soils are generally impacted through construction. This can include both facility construction and construction associated with changes in land use patterns. Since very few changes are anticipated in land use patterns as a result of the project, soil impacts will be primarily restricted to construction activities. This parameter was assigned a weight of "1" indicating slight importance.

Surface Water Quality: Surface water quality can be impacted by a wide range of factors and activities. The operation of a treatment facility can be a beneficial or detrimental factor depending upon the current condition of the surface water and the quality of the effluent. Construction activities are generally negative in nature and due to increased sediment loads. Secondary growth can have a negative impact associated with increased urban runoff. An assessment of current water quality and project issues indicates the surface water quality is a highly significant parameter and as such was assigned a weight of "4".

Groundwater - Free Flow: This parameter includes an assessment of both the quality and quantity of the free flowing groundwater. This component of the groundwater is discussed in the Environmental Inventory Technical Reference Document and is exemplified by the flow in Buggytop Cave. This parameter is regarded as highly significant (4) since it provides the habitat for the relatively sensitive aquatic cave systems and due to the fact that the free flowing groundwater appears to resurface in the Highland Rim.

Groundwater - Diffuse: The diffuse component of the groundwater is also described in the Environmental Inventory Technical Reference Document. The use of land disposal techniques or septic systems can impact the diffuse groundwater component. Due to the limited use of wells as a drinking water source, the diffuse component of the groundwater was assigned a moderate level of importance (2).

Aquatic Biology: The direct impact of treatment facilities on the aquatic biological systems is graphically illustrated in the environmental inventory. The degraded environmental conditions downstream of the current discharge point are in sharp contrast to the generally healthy conditions found elsewhere in the study area. Indirect effects can also be caused by construction activities and secondary growth. Due to the current inputs on the aquatic systems, this parameter was assessed as being highly significant (4).

Cave Biology: The extensive number of cave systems in the study area is documented in the environmental inventory. The cave communities, both aquatic and terrestrial, are exceedingly sensitive to pollution.

The increased nutrient or suspended solid levels associated with waste treatment systems can be extremely disruptive to these systems. Because of the extensive number of caves and the cave community sensitivity to pollution, this parameter was assigned a weight of "4" -- highly significant.

Terrestrial Ecology: This parameter includes both terrestrial flora and fauna. A wide variety of terrestrial communities has been documented in the environmental inventory. Impacts to terrestrial communities will be primarily associated with construction activities. The terrestrial ecology parameter has been assigned a weight of "3" (significant).

Protected Species: Several rare and endangered (protected) species have been identified in the study area. These species include organisms in the parameter categories of Aquatic Biology, Cave Biology and Terrestrial Ecology. The protected status of these organisms requires that the parameter be assigned a weight of "4" -- highly significant.

Sensitive Areas: The category of sensitive areas is used to emphasize those communities or areas which are not adequately included under the other parameters. These areas may include physically distinct areas such as marshes or they may represent communities or individuals which are not legally considered rare or endangered but are of local interest. The sensitive area parameter has been assigned a weight of "3" - significant.

Man-made Environment - Parameters & Weights

Cultural Resources: The cultural resources of an area not only include historical and archaeological sites but are defined, in part, by local attitudes. The Sewanee area has a distinctly high level of cultural awareness which is reflected in the large number of cultural resource sites detailed in the Environmental Inventory Technical Reference Document. Due to the large number of sites and the local concern over cultural resources, this parameter has been weighted as significant (3). Recreational Resources: Recreation is a vital part of the life styles found within the study area due to the age and economic distribution of the Sewanee population. Any wastewater management plan has the potential for impacting recreational activities and resources. Due to the local emphasis on recreation and the current use or potential use of many areas for recreational activities, a weight of "3" has been assigned to the recreational resource parameter.

Transportation: Transportation facilities can be impacted through construction activities and increased demand associated with secondary growth. The latter development is not anticipated. It is possible that some interruption of normal highway traffic could be caused by pipeline construction. Because of the limited scale of such an interruption, this parameter has been assigned a weight of "1" -- slight.

Resource Use: Mineral production and timber production represent the major resource uses in the study area. However, the 1970 employment statistics indicate that only 7.5 percent of the Franklin County population is employed in agricultural or forestry activity and that only 0.2 percent is employed in mining activity. The University of the South, though, has in the past generated considerable funds from the selling of timber rights. Due to the economic potential of many of the forest lands, the parameter of Resource Use has been assigned a weight of "2" - moderate.

Water Supply: The Sewanee water supply is contained on top of the Cumberland Plateau and is unaffected by the Sewanee Treatment Plant. Individuals residing in Lost Cove and along Crow Creek utilize individual wells and springs as their water supply. The area of Sherwood maintains a central spring water source as a water supply. Cowan uses Boiling Fork Creek as a water supply. Construction activity and effluent disposal can seriously impact water supply sources. The magnitude of potential impacts requires that water supply be weighted as highly significant (4).

Community Services: Community Services include health care, education and libraries, fire protection, police protection and the administrative structure to manage these services. Impacts to community services are associated with increased population size. While such increases are not anticipated within the study area, the large costs associated with the expansion of community services mandates a weighting of moderate importance (2).

4. Environmental Evaluation of Alternatives

The environmental evaluation is completed by the assessing of weights and the calculations of scores for the natural and man-made parameters. The parameters, weighting factors, scores and alternative cumulative scores for the natural environment are summarized in Table IV-12 while Table IV-13 lists the same for the man-made environment. The evaluation of each of the eight alternatives is described below.

Alternative 1 - Upgrade existing STP, discharge to Depot Branch. This alternative had the highest score for the natural environment evaluation (47 points) but the second highest score for the man-made evaluation (25 points). The combined total (72 points) ranked Alternative 1 as the best alternative in terms of the environment. The only parameter to receive a negative rating in the analysis was the "Economic Conditions" of the man-made parameters. This was because of the high local annual costs associated with the alternative. The high overall score for this alternative was primarily due to the small amount of construction required, the lack of pipelines and the high quality effluent anticipated. A significant beneficial impact was projected for the aquatic biology parameter due to the effluent quality and increased operating reliability. The parameters of Odor, Surface Water Quality, Free Flowing Groundwater, Cave Biology and Water Supply were rated as moderately beneficial. These ratings were

TABLE IV-12

ENVIRONMENTAL EVALUATION PROCESS
NATURAL ENVIRONMENT
ENVIRONMENTAL PARAMETERS, WEIGHTING FACTORS, SCORES, AND ALTERNATIVE CUMULATIVE SCORES

		ALTERNATIVES							
			1		2		3		4
PARAMETER	WEIGHT	RATE	SCORE	RATE	SCORE	RATE	SCORE	RATE	SCORE
Climate	1	0	0	0	0	0	0	-1	-1
Air Quality	1	0	0	0	0	0	0	-1	-1
Odor	2	2	4	2	4	2	4	2	4
Noise	1	0	0	-1	-1	-2	-2	0	0
Topography	1	0	0	0	0	-2	-2	0	0
Geology	1	0	0	0	0	-1	-1	0	0
Soils	1	0	0	0	0	-2	-2	1	1
Surface Water									
Quality	4	2	8	2	8	2	8	3	12
Quantity	1	1	1	1	1	-1	-1	-1	-1
Groundwater									
Free Flow	4	2	8	2	8	1	4	1	4
Diffuse	2	1	2	1	2	1	2	2	4
Aquatic Biology	4	3	12	3	12	3	12	3	12
Cave Biology	4	2	8	2	8	2	8	2	8
Terrestrial Ecology	3	0	0	0	0	-4	-12	-2	-6
Protected Species	4	1	4	1	4	-3	-12	2	8
Sensitive Areas	3	0	0	0	0	-2	-6	0	0
NATURAL ENVIRONMENT TOTAL			47		46		-4		42

TABLE IV-12

(cont'd)

	ALTERNATIVES							
	5		6		7		NO-ACTION	
PARAMETER	RATE	SCORE	RATE	SCORE	RATE	SCORE	RATE	SCORE
Climate	-1	-1	-1	-1	-1	-1	0	0
Air Quality	-1	-1	-1	-1	-1	-1	0	0
Odor	2	4	2	4	2	4	-2	-4
Noise	0	0	0	0	0	0	0	0
Topography	0	0	0	0	0	0	0	0
Geology	0	0	0	0	0	0	0	0
Soils	1	1	1	1	1	1	-1	-1
Surface Water								
Quality	3	12	3	12	3	12	-2	-8
Quantity	-1	-1	-1	-1	-1	-1	0	0
Groundwater								
Free Flow	1	4	1	4	1	4	0	0
Diffuse	1	3	2	4	2	4	0	0
Aquatic Biology	3	12	3	12	3	12	-2	-8
Cave Biology	2	8	2	8	2	8	-2	-8
Terrestrial Ecology	-2	-6	-1	-3	-1	-3	0	0
Protected Species	2	8	2	8	2	8	-2	-8
Sensitive Areas	0	0	0	0	0	0	0	0
NATURAL ENVIRONMENT TOTAL		42		45		45		-37

TABLE IV-13

ENVIRONMENTAL EVALUATION PROCESS
MAN-MADE ENVIRONMENT
ENVIRONMENTAL PARAMETERS, WEIGHTING FACTORS, SCORES, AND ALTERNATIVE CUMULATIVE SCORES

Man-Made Environmental Parameter	Weight	Wastewater Management Alternatives							
		1		2		3		4	
		Rate	Score	Rate	Score	Rate	Score	Rate	Score
Population Characteristics	1	1	1	1	1	1	1	1	1
Land Use	1	1	1	1	1	1	1	1	1
Economic Conditions	2	-1	-2	-1	-2	-2	-4	-1	-2
Cultural Resources	3	2	6	2	6	-3	-9	-3	-9
Recreational Resources	3	3	9	3	9	-1	-3	-2	-6
Transportation	1	0	0	0	0	-3	-3	-3	-3
Resource Use	2	0	0	0	0	0	0	0	0
Wastewater and Water Supply Programs	4	2	8	2	8	1	4	1	4
Community Services and Facilities	2	1	2	1	2	1	2	1	2
Man-Made Environment Totals		25		25		-11		-12	

TABLE IV-13

(cont'd)

Man-Made Environmental Parameter	Wastewater Management Alternatives							
	5		6		7		No-Action	
	Rate	Score	Rate	Score	Rate	Score	Rate	Score
Population Characteristics	1	1	1	1	1	1	-1	-1
Land Use	1	1	1	1	1	1	-1	-1
Economic Conditions	-1	-2	-1	-2	0	0	-4	-8
Cultural Resources	2	6	2	6	2	6	0	0
Recreational Resources	-2	-6	3	9	3	9	-2	-6
Transportation	0	0	-1	-1	-1	-1	0	0
Resource Use	0	0	0	0	0	0	0	0
Wastewater and Water Supply Programs	2	8	2	8	2	8	-2	-8
Community Services and Facilities	1	2	1	2	1	2	-2	-4
Man-Made Environment Totals	10		24		26		-28	

associated with the general improvements in the wastewater treatment and in system reliability.

Alternative 2 - Construct new STP, discharge to Depot Branch. This alternative had the second highest natural environment evaluation (46 points), only one point less than Alternative 1. This score combined with the second highest man-made environment score (25 points) produced one of the second best overall scores (71 points). While Alternative 1 has the highest overall score, it is only one point greater than Alternative 2. The two alternatives are considered to be environmentally tally equivalent with the one point difference being attributed to the short-term negative impact of construction on the noise parameter. All other parameters received the same rates and scores as Alternative 1.

Alternative 3 - Upgrade existing STP, discharge to Elk River. The extensive construction and pipeline activities associated with this alternative indicate a substantial degree of negative impacts. These impacts are reflected in the natural (-4) and man-made (-11) evaluations which cumulatively are the lowest of the action alternatives. A highly significant negative rating was assessed for the Terrestrial Ecology parameter. The extensive construction activity associated with the pipeline from the present site to the Elk River would be a major intrusion on the terrestrial community. The alternative could also affect rare and endangered species. Saxifraga careyana is a plant listed on the Federal Threatened Species list and known to be present in the mixed mesophytic forest on the north side of the plateau. In addition, the discharge of effluent to the Elk River could impact two species on the Federal Endangered Species list (River Snail - Io Verrucosa; Pale Lilliput Pearly Mussel - Toxoplasma cylindrella) and one species listed as threatened on the Federal list and as endangered on the State of Tennessee list (Umbilicate river snail - Anculosa subglobosa form umbilicata). The alternative would produce moderate negative impacts on noise (construction), topography (escarpment/ pipeline), soils (erosion) and sensitive areas (Mixed mesophytic forest). The alternative would produce moderate beneficial impacts on the categories of Odor, Surface Water Quality, Aquatic Biology and Cave Biology. These beneficial impacts are associated with the improvement of the treatment facility and the transfer of the effluent from Depot Branch to the Elk River. The man-made environmental score is the lowest partially due to the fact that this alternative has the higher local annual costs.

Alternative 4 - Upgrade existing STP, spray irrigation at Rutledge Point site. The extensive construction and pipeline activities and the using of a recreational/cultural resource area for land application of treated wastewater associated with this alternative indicates a substantial degree of negative impacts. These impacts are reflected in the two evaluations, particularly with the man-made evaluation score (-12). The two scores cumulatively (30) put this alternative at the fifth ranking out of eight. The major beneficial aspects of the alternative are the improvements to surface water quality and water supply resources. The complete removal of the effluent from the surface streams account for most of the benefits while the addition of the sprayfield should increase the diffuse groundwater supply to some extent.

Alternative 5 - Construct new STP (Facultative Lagoon) at spray site; spray irrigation at Rutledge Point site. The natural environmental score for this alternative is identical to Alternative 4's score. The man-made environmental score for this alternative is higher than the score for Alternative 4 because the impacts on cultural resources and on water supply programs are shown to be more positive for this alternative. A combined score of 52 ranks this alternative as fifth out of eight.

Alternative 6 - Upgrade existing STP; spray irrigation at St. Marys and Garnerstown sites. This land application alternative has higher positive scores for diffuse groundwater impacts and less negative scores for terrestrial ecological impacts (due to less pipeline construction) than the scores for Alternatives 4 and 5. The man-made environmental scores are higher, particularly the score for the impact on recreational resources. This is because these spray irrigation sites are rural forested areas that are not used for recreational purposes. The total environmental score (69) ranks as third among the eight alternatives.

Alternative 7 - Construct new STP (Facultative Lagoon) at spray site; spray irrigation at St. Marys and Garnerstown sites. This alternative is ranked in second place along with Alternative 2. The natural environmental score is identical to the score estimated for Alternative 6 but the man-made environmental score is higher (more positive) because this alternative has the lowest local annual costs associated with its construction.

No-Action Alternative - The no-action alternative assumes no federal involvement in the study area. According to the environmental evaluation, this is the least desirable alternative. No-action in the study area would potentially negatively impact several aspects of the environment including odor, soil, surface water quality, aquatic and cave biology, protected species, population, land use, economic conditions, recreational resources, wastewater and water supply programs and community services and facilities. The cumulative score for the no-action alternative is -65.

5. Summary

The results of the environmental evaluation are summarized in Table IV-14 to enable the alternatives to be ranked according to their total environmental score (natural + man-made environmental scores). The natural environmental evaluation scores indicate that Alternative 1 is the most desirable alternative of the eight that are evaluated. Alternatives 2, 6 and 7 came out to be essentially equivalent, with Alternative 2 ranked as second, with only one point above the other two. Alternatives 4 and 5 were rated slightly lower, primarily due to the more extensive pipeline associated with these alternatives. Alternative 3 and the no-action alternative were the least desirable, and no-action had the lowest score.

TABLE IV-14

ENVIRONMENTAL RANKING OF ALTERNATIVES

Alternative	Natural Environmental Score	Man-Made Environmental Score	Total Environmental Score	Ranking
1	47	25	72	1
2	46	25	71	2
3	-4	-11	-15	6
4	42	-12	30	5
5	42	10	52	4
6	45	24	69	3
7	45	26	71	2
No-Action	-37	-28	-65	7

The man-made environmental evaluation scores indicate that Alternative 7 is the most desirable alternative, followed very closely by Alternatives 1, 2 and 6. Alternatives 3, 4 and 5 received low scores, basically because of the more extensive construction associated with implementation of these alternatives. The no-action alternative is the least desirable.

The total environmental scores indicate that Alternatives 1, 2 and 7 are the most desirable alternatives for implementation in the study area. Alternative 3 and the no-action alternative are the least desirable according to the environmental evaluation.

PART F. IMPLEMENTABILITY EVALUATION

System implementability considers the practicalities of implementing a specific wastewater management alternative within the study area. The implementability evaluation rating provides a method for assessing the factors that affect the successful implementation of the alternatives based on public and institutional realities. The three factors to be considered and assessed are public acceptability, management concerns, and planning flexibility.

Unlike the other evaluations in the cost-effectiveness analysis (costs, operability, and environmental impact), the implementability rating is not independent, but rather is somewhat dependent on the results of the other evaluations. This is especially the case with public acceptance which is very much influenced by the estimated users costs and the environmental impacts of the various alternatives.

Public Acceptability

Public acceptability of a wastewater facilities plant is crucial to its total implementability. If a proposed plan faces stiff opposition from the public, its implementation possibilities are seriously diminished. An important concern to the public is the affect a particular alternative will have on the local financial capabilities. This can be evaluated by using the local annual costs determined in Section 4, Part C. These costs include the annual operation and maintenance costs plus the annualized local share of the cost of constructing the wastewater facilities. This is a measure of annual revenue requirements and, therefore, the actual users costs. These costs are listed in Table IV-7. Also determined was the users local annual costs for the new project plus existing annual costs presently being incurred and which will continue as an expense. These costs are listed in Table IV-8 and are referred to as the indebtedness for past and proposed wastewater projects. The average residential annual billing cost (Table IV-8, last row) is the cost utilized in this evaluation of public acceptance.

The environmental impacts of a specific wastewater management alternative are divided into two parts for evaluating public acceptance. The two parts, type of treatment facilities and type of disposal both affect the environment and thereby concern the public.

The type of treatment facilities varies according to the level of the treatment desired and the option of upgrading existing units or building all new facilities. The proposed alternatives range from a highly sophisticated, conventional activated sludge unit to the very simple, alternate facultative lagoon. The conventional treatment facilities have been proven to be completely acceptable due to their high reliability and flexibility. The proposed alternate facultative lagoon has created considerable concern among the citizens, mainly due to the lack of available information on successful lagoon performance in the State of Tennessee.

The disposal methods for the alternatives involve either discharge to surface water (Alternatives 1, 2, and 3) or land application (Alternatives 4, 5, 6 and 7). The public acceptability of surface water discharge poses no problem; however, spray irrigation alternatives do often arouse adverse public reaction. Based upon prior Citizen's Review Group meetings and communications from the University of the South, land application in the Sewanee area does not seem to be a potential problem in terms of public acceptability. Most people on the Citizen's Review Group have expressed interest in implementing land application of wastewater effluent.

The ownership of the University of all lands in and around the proposed spray sites is a positive aspect for spray irrigation in that growth can be effectively controlled by the University in these areas, avoiding future development near the spray sites which might lead to conflicts between community development and the Utility district. Another concern when viewing the disposal methods is the amount of construction required for conveyance of effluent to the discharge point. Alternatives 3, 4, and 5 would all require a substantial amount of construction through the town which would be very disruptive. This, therefore, would cause some public resistance to these alternatives.

Management Concerns

Another factor to be considered in the implementation of an alternative is management concerns. It is assured that the Sewanee Utility District will continue to own and operate the wastewater facilities. This will help in providing continuity of management throughout the selected project.

The land application alternatives may present some problems due to the necessity of proper operation of spray irrigation facilities to avoid odor, aerosol and runoff problems. Experience in these types of management operation problems is not generally available among conventionally-trained trained wastewater treatment plant operators.

Planning Flexibility

The final factor in implementability is that of planning flexibility. Planning flexibility is a measure of which alternative will provide the greatest latitude for future planning decisions. This mainly concerns the commitment of large tracts of land for a specified land use under the proposed land application alternatives. The ability of all alternatives to adjust to changes created by future planning decisions in wastewater flow (both volume and pollutant load) and changes in water quality goals was addressed in the operability evaluation.

For purposes of presenting an overall ranking for implementability, Table IV-15 was assembled with a ten (10) rating representing the most desirable scoring in each category. The ranking of overall implementability indicates Alternative 2 to be the most desirable with Alternatives 1 and 7 providing close seconds. It should be noted that the land application alternatives (4 and 5) utilizing Rutledge Point site will be eliminated due to the unacceptability of this site as a spray irrigation site according to the University of the South. From experience, much emphasis is put on the local annual costs for the final implementability evaluation. This, in turn, highly favors the land application alternatives with Alternative 7 having the lowest cost.

PART G. EVALUATION OF THE NO-ACTION ALTERNATIVE

A requirement of the EIS process developed by EPA is that a no-action alternative be explored along with other wastewater facilities alternatives. The no-action alternative implies that no federal funding would be available for wastewater facilities in the Sewanee area. Under this scenario, improvement and/or expansions of the wastewater facilities would be required but there would be no federal funds provided for design and construction of the facilities.

No-action does not imply no-growth in the study area. However, it would possibly alter growth throughout the area. Under this concept there would be complete reliance upon state, local or private funds to finance any wastewater management facilities. However, without the support of federal funds the amount and nature of additional treatment facilities would be significantly different than under any of the other wastewater management alternatives.

Under a no-action scenario it is likely that most future sewage treatment and disposal needs would be accomodated by either privately-owned package treatment plants or individual on-lot treatment systems (e.g. septic tanks). Generally under a no-action alternative there are significant impacts upon the rate of growth, the pattern of growth and the overall cost of wastewater management.

The missing component in this alternative is the federal capital funding for wastewater management. Considering the magnitude of the

TABLE IV-15

WASTEWATER MANAGEMENT ALTERNATIVES IMPLEMENTABILITY EVALUATION RANKING

Alternative	Public Acceptability	Management Concerns	Planning Flexibility	Overall Implementability	Ranking
1 - Upgrade existing STP. Discharge to Depot Branch	8	9	9	26	2
2 - Construct new STP. Discharge to Depot Branch	9	9	9	27	1
3 - Upgrade existing STP. Discharge to Elk River	5	10	10	25	3
4 - Upgrade existing STP. Spray irrigation at Rutledge Point site	5	9	8	22	5
5 - Construct new STP. Spray irrigation at Rutledge Point site	7	9	8	24	4
6 - Upgrade existing STP. Spray irrigation at St. Marys and Garnerstown sites	8	9	8	25	3
7 - Construct new STP. Spray irrigation at St. Marys & Garnerstown sites	9	9	8	26	2

capital cost of any structural wastewater management systems for the basin, it is highly unlikely that any such system could be constructed if 100 percent of the cost had to be borne by state and local governments (as compared with the 25 percent state-local share that is currently required under Section 201 for construction grants). However, it is reasonable to expect that other methods of sewage treatment would emerge in response to development pressures.

The controls over development pressures in the Sewanee area are much different than they are in most areas. Most of the study area is within the Domain of the University of the South, therefore, development can easily be controlled by the University as required. For the purposes of this study the following is a portrayal of what would most likely occur under a no-action alternative.

1. Renovations would possibly be made to the existing treatment plant in an attempt to bring the treatment plant into compliance with the existing effluent limitations imposed by the NPDES permit. These renovations would be paid for by local funds, however, it is unlikely that local funds would be sufficient for any significant renovations or additions to the treatment plant or the collection system. Both the University of the South and the Sewanee Utility District would be hard pressed in view of their current financial obligations to raise any significant funds for plant improvements. Consequently plant renovations and/or improvements would allow no additional treatment capacity nor would the renovations be significant enough to meet NPDES effluent limitations at the existing effluent outfall. Therefore, the plant would continue to operate at existing hydraulic levels and would continue to violate NPDES effluent limitations for Depot Branch or Lost Creek.

2. With the restrictions on the treatment plant, there would be no additional connections to the treatment plant. Consequently any new construction in the study area would utilize either on-lot disposal systems or package plants. Since most of the development would not be significant enough to justify a package plant it must be assumed that most sewage disposal would be through the use of on-lot systems. The potential proliferation of on-lot systems would only add to the current problems with malfunctioning septic tanks. Many of the soils on the plateau are very shallow and have minimal depths to bedrock. Most of these soils have a severe soil limitations rating for septic tank absorption fields. However, the use of alternative on-lot systems such as raised sand mounds could be utilized where soils are insufficient for conventional on-lot septic systems.

Under the no-action alternative, as portrayed by this scenario, we would expect to see very little development and virtually no changes in the existing land use patterns. This also holds true for population growth. Currently, some population growth is projected for the Sewanee area by the year 2000. Since the University does not anticipate significant increases in enrollment, much of the new growth would be residential growth within the Sewanee area. However, if a no-action scenario occurs, population growth in the area will be less than what is projected. Without the availability of a new sewage treatment plant and collection system extensions, new residential growth will be impeded as will any enrollment increases at the University.

A no-action alternative would influence land use in the Sewanee area in that it would probably encourage scatter development, particularly outside the Domain of the University of the South where development would not be controlled by the University. Scatter development refers to construction activity that would take place on an unplanned basis throughout the study area and would not be influenced by the construction of wastewater facilities. Scatter development would utilize on-lot sewage disposal systems and, therefore, would occur on large lots and in those areas suitable for on-lot systems.

Finally, the environmental impacts of a no-action alternative must be reviewed. The selection of a no-action alternative will have two significant environmental impacts. First, the treatment plant will continue to be a major source of pollution in the watershed, and the violation of effluent standards in Depot Branch will probably continue. Secondly, the area will probably see a proliferation of on-lot septic systems which may cause contamination of lakes and groundwater supplies. These on-lot systems may, due to shallow soil in some regions of the study area, eventually malfunction and cause potential public health problems.

In summary, the following conditions would probably occur with the selection of a no-action alternative:

1. Little or no changes in the existing sewage treatment and collection system. Proliferation of on-lot disposal systems.

2. Reduced population growth well under year 2000 projection. Diminished opportunities for enrollment growth at the University.

3. Less residential development and a continuation of uncontrolled scatter development outside of the boundaries of the Domain.

4. A continuation of present environmental problems related to on-lot disposal systems and those occurring in the Depot Branch watershed from poorly treated wastewater at the existing treatment plant.

APPENDIX A

"Auger Boring Investigation for the Proposed Spray Irrigation Site - Sewanee, Tennessee" Soil Systems, Inc.

AUGER BORING INVESTIGATION
FOR THE
PROPOSED SPRAY IRRIGATION SITE
SEWANEE, TENNESSEE

JOB NO. 472-05028

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
ENGINEERS AND PLANNERS
P. O. BOX 1963
HARRISBURG, PENNSYLVANIA 17107

NOVEMBER 18, 1980

BY

SOIL SYSTEMS, INC.
525 WEBB INDUSTRIAL DRIVE
MARIETTA, GEORGIA 30062

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AUGER BORING INVESTIGATION

INTRODUCTION

General

During the period of October 27, 1980 to November 6, 1980, Soil Systems, Inc. performed a series of 56 auger borings to aid in the assessment of three proposed land treatment sites for use by the Sewanee Utility District in Sewanee, Tennessee. The purpose of these borings was to determine the thickness and nature of the soil and prevailing groundwater conditions at each site.

Authorization to perform this investigation was in the form of a subcontract agreement number 5-7443-01 between Gannett Fleming Corddry and Carpenter, Inc., Engineers and Planners and Soil Systems, Inc.

SITE LOCATIONS

Three areas are currently under consideration. The two sites southwest of Sewanee have been designated the St. Mary's and Garnertown Sites. The site to the northwest of town is the Rutledge Point Site. Site location maps are included in the appendix.

GEOLOGY

The town of Sewanee is located on the top of Monteagle Mountain which is part of the Cumberland Plateau Physiographic Province. The structure of the mountain is a syncline consisting of limestones and shales overlain by a sandstone cap. This unit, the Pottsville Formation, is the parent rock of the soils present at all three sites and is visible in outcrops at each site. The weathering profile of the unit is variable as evidenced by the wide variation in depths to refusal.

FIELD INVESTIGATION

The borings were performed by an all terrain vehicle mounted CME 45 drill rig turning continuous flight augers. The borings were located by pacing distances and turning angles using a compass. The drilling program was supervised by an engineering geologist from Soil Systems, Inc. in the presence of Mr. Bernard Markunas of Gannett Fleming Corddry and Carpenter, Inc., Engineers and Planners. Boring location plans and a log of each boring appears in the appendix of this report.

SUBSURFACE CONDITIONS

At the St. Mary's site the depth to refusal varied from 2.2 feet to 21.2 feet. Generally the upper two to eight feet of the boring was easily penetrated by the auger at which point drilling resistance increased steadily until refusal was reached. The soils encountered were generally silty sands to sandy silts. All borings reached refusal in the sandstone unit.

At the Garnertown Site, the range of depths was from 3.4 feet to 33.3 feet. The drilling conditions and soil types were similar to the first site. In boring B-19, the sandstone unit was penetrated at a depth of approximately 18 feet. The gray silty clay at the depth encountered is presumed to be the Pennington shale, a unit of Mississippian age which occurs stratigraphically beneath the Pottsville Formation. All other borings reached refusal in the sandstone unit.

At the Rutledge Point Site, the refusal depths ranged from 2.4 feet to greater than 20 feet. Soil conditions were again similar to the first two sites except that the depth to auger refusal was generally less than at the St. Mary's and Garnertown Sites. At this site, boring B-6 penetrated the sandstone at a depth of approximately 12 feet. This boring was the deepest one drilled at Rutledge and was terminated at 20 feet after establishing a substantial thickness of the gray silty clay.

SUMMARY

In summation, the subsurface conditions encountered at all three sites are quite similar. Soil thicknesses are equal to or greater than the expected two to six feet and the soils are of a sufficiently granular nature to warrant further investigation of permeability and other physical properties pertaining to percolation rates. Groundwater was not encountered in any of the borings; groundwater is not expected to cause difficulties for the purposes of this investigation.

Respectfully submitted,

SOIL SYSTEMS, INC.

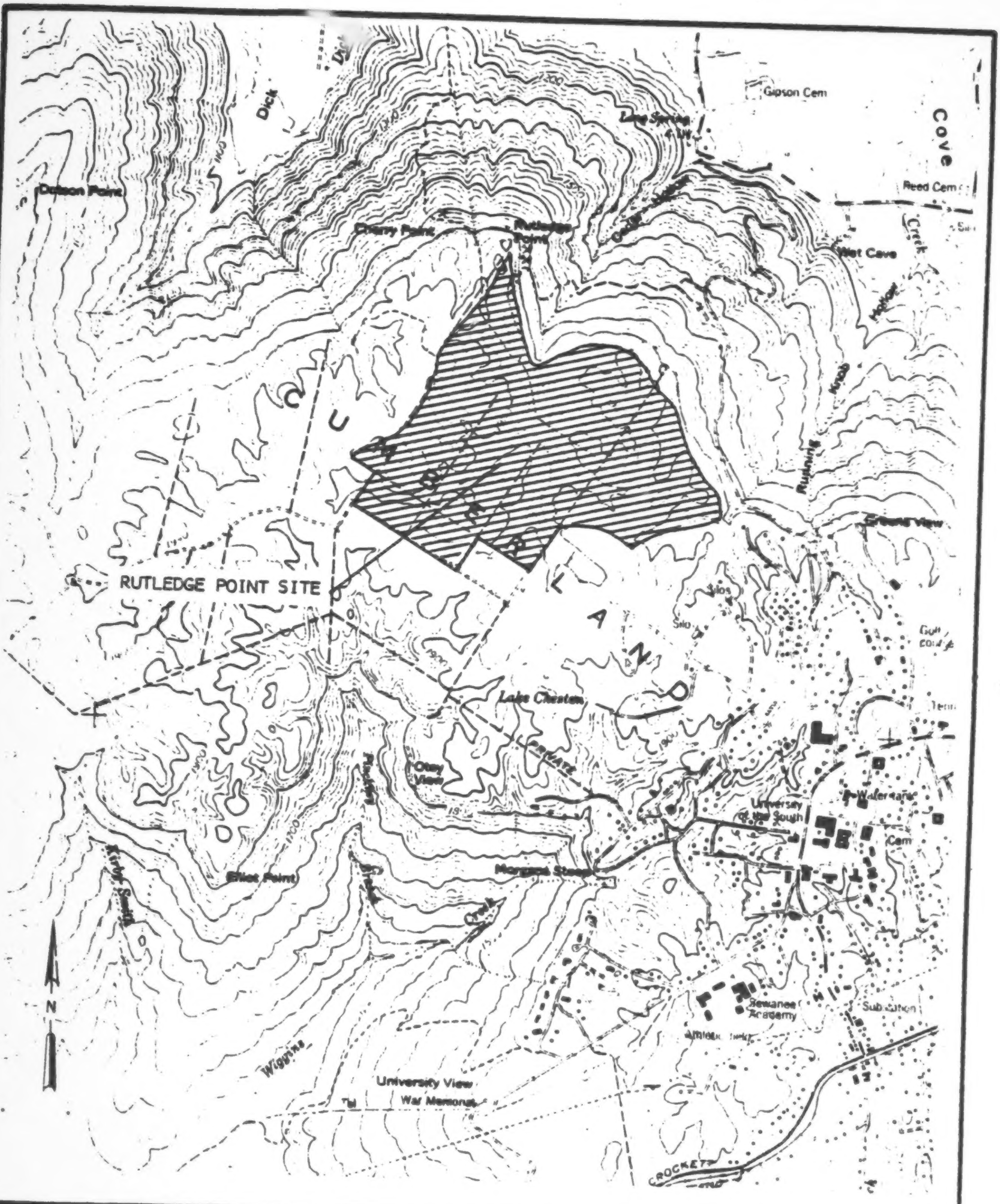
Robert M. Whitaker

Robert M. Whitaker
Project Geologist

Frank O. Mikle

Frank O. Mikle, P.E.
Vice-President

APPENDIX


Dick
Dodson Point
Cherry Point
Rutledge Point
Long Spring
Gipson Cem
Cove
Reed Cem
Wet Cave
Creek
Hollow
Knob
Running
Grand View
C U M B E R L A N D
RUTLEDGE POINT SITE
Silos
Silo
Golf course
Lake Cheston
Otey View
Elliot Point
Kirby Smith
Morgans Steep
University of the South
Waterworks
Cem
Sewanee Academy
Athletic field
Substation
Wiggins
University View
War Memorial
CROCKETT
N
1900
2000

Legend

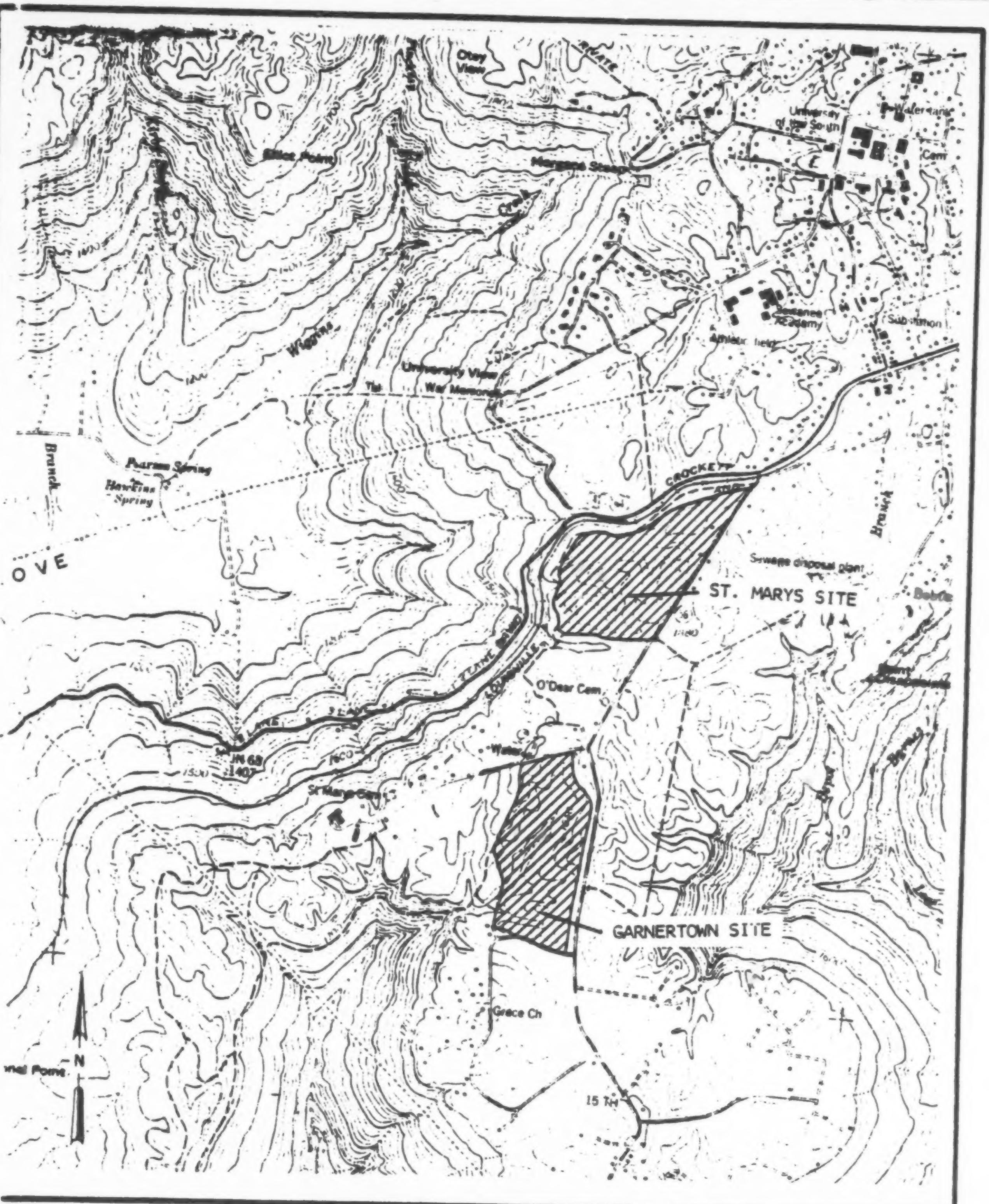
Rutledge Point Site Location

Scale: 1'' = 2000'

Soil Systems, Inc.

Project

Proposed Spray Irrigation Site
Sewanee, Tennessee


Otey View
University of the South
Morgans Steep
University View
War Memorial
Wiggins
Pearson Spring
Hawkins Spring
Branch
O V E
Sewanee Academy
Athletic field
CROCKETT
Sewage disposal plant
ST. MARYS SITE
O'Dear Cem
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St Marys Conv
GARNERTOWN SITE
Grace Ch
N

Legend

t. Mary's and Garnertown Site
ocations

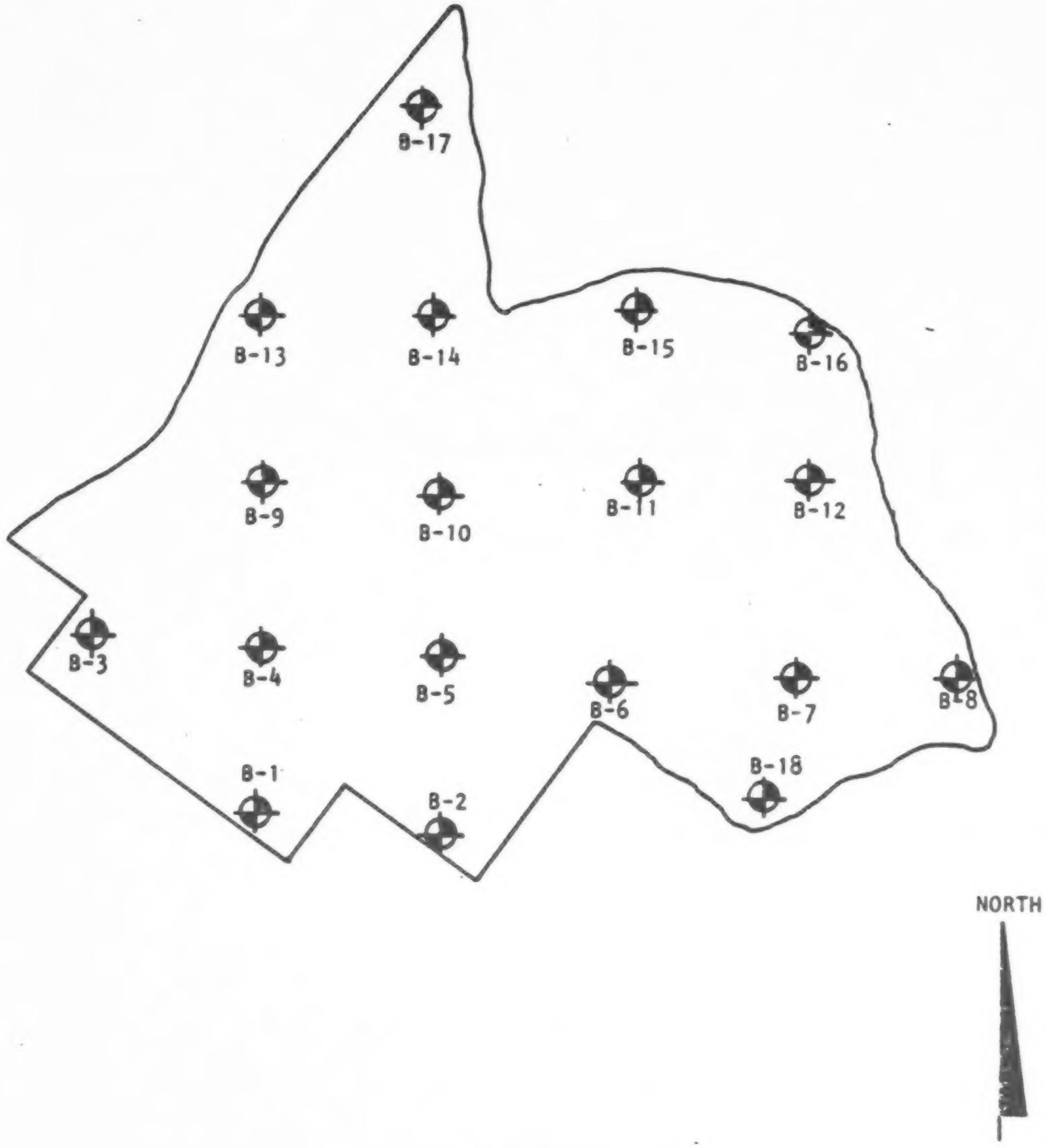
Scale: 1" = 2000'

Soil Systems, Inc.

Project

Proposed Spray Irrigation Sites
Sewanee, Tennessee

BORING LOGS FOR RUTLEDGE SITE


B-17
B-13
B-14
B-15
B-16
B-9
B-10
B-11
B-12
B-3
B-4
B-5
B-6
B-7
B-8
B-1
B-2
B-18
NORTH

Legend

Location of Borings

Scale: 1" = 1000'

SSI
Soil Systems, Inc.

Project

Proposed Spray Irrigation Site
Rutledge Point Site
Sewanee, Tennessee

RECORD OF SUBSURFACE EXPLORATION

Boring B-1

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Tan-orange and brown silt, trace clay and fine sand	5					
Auger refusal @ 7.6'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-2

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Light brown-orange sandy silt						
Auger refusal @ 4.2'	5					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-3

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Light brown sand with silt and gravel						
Auger refusal @ 4.2'	5					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-4

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Light brown silty sand						
Auger refusal @ 4.1'	5					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-5

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Tan silty fine sand						
Light brown fine sandy silt	5					
Tan sandy silt with sand	10					
	15					
Auger refusal @ 18.1'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-6

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-4-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange clayey silt, trace gravel and sand	5					
Tan silty clay	10					
Gray clayey silt with sand, trace gravel	15					
Boring terminated @ 20.0'	20					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-7

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown-red sand with silt, trace gravel						
Light brown-red sand, trace silt	5					
Auger refusal @ 4.4'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-8

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange-tan sandy silt						
Auger refusal @ 4.0'	5					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

SSI

Boring B-9

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange-tan sand with silt, trace gravel	5					
Brown silty sand						
Tan silt with sand and gravel	10					
Auger refusal @ 10.6'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

SSI

Boring B-10

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-4-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange-tan sand with silt						
Auger refusal @ 2.4'						No water table encountered @ 0hrs
	5					

RECORD OF SUBSURFACE EXPLORATION

Boring B-11

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silt with coarse sand						
Tan and orange silt, trace gravel and sand	5					
Auger refusal @ 8.4'	10					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-12

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-4-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange-tan sandy silt, trace gravel						
Tan-orange silty sand	5					
Auger refusal @ 4.6'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-13

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-4-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange-tan sandy silt, trace gravel						
Tan and orange silty sand, trace gravel	5					
Auger refusal @ 6.7'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-14

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Tan sand with silt and gravel						
Orange sandy silt, trace gravel	5					
Auger refusal @ 5.8'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-15

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown-orange silt, trace sand and gravel						
Tan-orange sand, trace silt and gravel	5					
Auger refusal @ 4.4'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-16

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Tan sand with silt and gravel						
Auger refusal @ 3.0'						
	5					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-17

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-5-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Tan-orange silt with sand and gravel						
	5					
Tan, gray, light-brown silt with clay, gravel and sand						
Auger refusal @ 7.7'	10					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-18

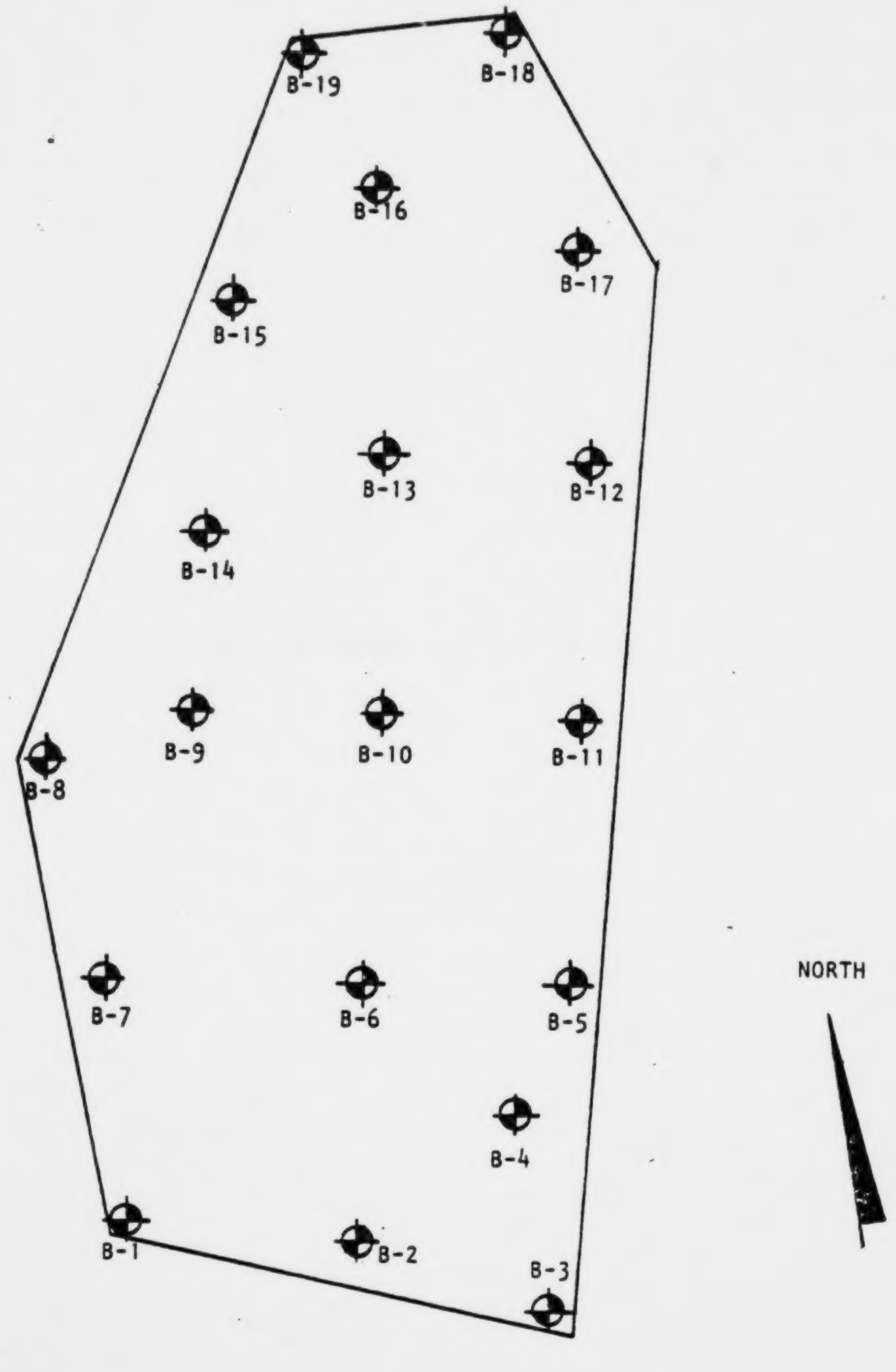
SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-6-80

Site: Rutledge Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown tan silt with sand						
Auger refusal @ 2.7'						No water table encountered @ 0hrs
	5					

BORING LOGS FOR GARNERTOWN SITE


B-19
B-18
B-16
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B-9
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B-11
B-8
B-7
B-6
B-5
B-4
B-1
B-2
B-3
NORTH

Legend

Location of Borings

Scale: 1" = 400'

SSI

Soil Systems, Inc.

Project

Proposed Spray Site
Garnertown Site
Sewanee, Tennessee

RECORD OF SUBSURFACE EXPLORATION

Boring B-2

SSI

Project Name: Proposed Spay Irrigation Site **Date of Boring:** 11-3-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silt with sand, trace clay						
Tan-brown sand with silt	5					
Auger refusal @ 7.1'						No water table encountered @ 0hrs
	10					

RECORD OF SUBSURFACE EXPLORATION

Boring B-3

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-3-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silt with sand						
Tan sand with silt, trace gravel	5					
Pale tan silty fine sand	10					
Auger refusal @ 10.1'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-4

SSI

Project Name: Proposed Spary Irrigation Site **Date of Boring:** 11-3-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silt with sand, trace clay						
	5					
Brown and tan sand with silt						
Auger refusal @ 7.8'						No water table encountered @ 0hrs
	10					

RECORD OF SUBSURFACE EXPLORATION

Boring B-5

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-31-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange-brown silty sand						
	5					
Brown-orange sand, trace silt						
Brown-tan fine sand with silt	10					
Gray-tan sand, trace silt						
Brown-tan sand, trace silt more tan and more silty with depth	15					
Auger refusal @ 17.2'						No water table encountered @ 0hrs
	20					

RECORD OF SUBSURFACE EXPLORATION

Boring B-6

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-3-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silty with sand	5					
Auger refusal @ 6.1'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

SSI

Boring B-7

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-4-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05025

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange-tan silty fine sand, trace gravel	5					
Orange-tan-pink fine sand with silt						
Auger refusal @ 7.3'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-8

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-4-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Dark tan, orange silt, trace sand						
	5					
Tan sand with silt						
Auger refusal @ 6.4'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-9

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-4-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown-orange silt with sand	5					
Tan silt, trace fine sand, trace clay						
Tan-brown silty sand	10					
Tan silt with fine sand	15					
Auger refusal @ 15.8'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-10

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-31-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silt with sand, some plant matter						
Orange-brown-tan silt with sand	5					
Orange-tan sand with silt	10					
Tan-orange silt with fine sand some trace clay						
Tan-orange silt with tan sand trace clay	15					
Tan-gray silt with clay, trace fine sand	20					
Auger refusal @ 21.3'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-11

Project Name: Proposed Spray Irrigation Site
Date of Boring: 10-31-80
Site: Garnertown Site, Sewanee, Tennessee
Project No.: 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange-brown silty sand	5					
Tan-orange sand with silt	10					
Orange-tan sand trace silt						
Tan-gray silt, trace tan sand trace clay	15					
Tan-orange silt with sand, trace clay						
Orange-brown sand with silt, trace gravel and clay	20					
Brown silt with sand, trace clay and gravel	25					
Auger refusal @ 26.1'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-12

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-31-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown-orange silt with sand						
Brown-orange silty sand	5					
Orange-tan sand with silt	10 15 20					
Auger refusal @ 22.1'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-13

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-4-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown-orange silt with sand and gravel						
Auger refusal @ 3.4''	5					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-14

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-4-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silt, trace fine sand, trace clay, trace gravel						
Auger refusal @ 4.7'	5					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-15

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-30-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Tan-orange silty sand	5					
Orange-tan silt with clay, trace gravel	10					
Tan-brown silt with clay	15					
Brown silt with fine sand, trace clay						
Tan-gray clayey silt	20					
Auger refusal @ 21.6'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-16

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-30-80

Site: Garnertown Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silt with sand, trace clay, gravel						
Tan-yellow silt with fine sand	5					
Tan-brown-orange silt with clay trace fine sand						
Auger refusal @ 8.0'						
	10					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-17

Project Name: Proposed Spray Irrigation Site Date of Boring: 10-30-80

Site: Garnertown Site, Sewanee, Tennessee Project No.: 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown sand with decomposed plant matter						
Orange-brown sand with silt	5					
Tan fine sand with silt	10					
Dark gray-brown silt, trace sand, trace clay						
Dark gray silt with sand and gravel, rock fragments	15 20					
Auger refusal @ 20.3'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-18

SSI

Project Name: Proposed Spray Irrigation Site Date of Boring: 10-30-80

Site: Garnertown Site, Sewanee, Tennessee Project No.: 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange-brown silty sand trace gravel						
	5					
Orange silt, trace sand, trace clay						
	10					
Orange silt with sand trace gravel						
Auger refusal @ 12.2'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

SSI

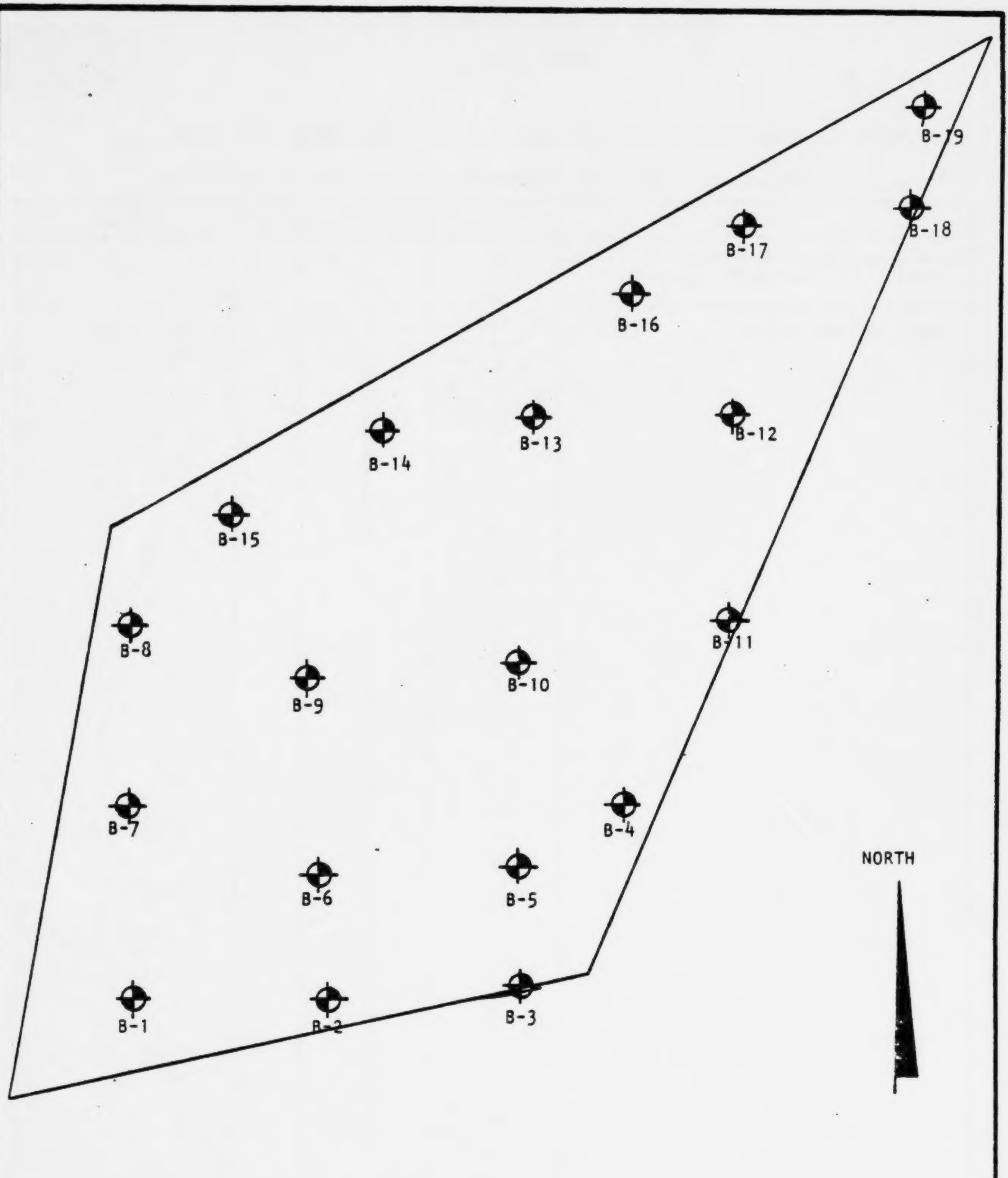
Boring B-19

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-30-80

Site: Garnertown Site, Sewanee, Tennesse **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown-orange sandy silt, trace gravel						
Dark orange silt, tracy clay, trace fine sand	5					
Brown-orange-pink fine sand with silt	10					
Brown silty sand, trace clay	15					
Brown silt with clay, trace sand, trace sand stone fragments,						
Gray silty clay, trace sand	20 25					
Light gray clay with silt	30					
Boring terminated @ 33.3'						No water table encountered @ 0hrs

BORING LOGS FOR ST. MARY'S SITE


B-19
B-18
B-17
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B-8
B-11
B-10
B-9
B-7
B-4
NORTH
B-6
B-5
B-1
B-2
B-3

Legend

Location of Borings

ale: 1'' = 400'

Soil Systems, Inc.

Project

Proposed Spray Irrigation Site
St. Mary's Site
Sewanee, Tennessee

RECORD OF SUBSURFACE EXPLORATION

SSI

Boring B-1

Project Name: Proposed Spray Irrigation Site
Date of Boring: 10-28-80

Site: St. Mary's Site, Sewanee, Tennessee
Project No.: 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silty sand with organics						
Auger refusal @ 2.2'						No water table encountered @ 0hrs
	5					

RECORD OF SUBSURFACE EXPLORATION

SSI

Boring B-2

Project Name: Proposed Spray Irrigation Site
Date of Boring: 10-28-80
Site: St. Mary's Site, Sewanee, Tennessee
Project No.: 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Tan and orange silty fine sand						
	5					
Auger refusal @ 5.5'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-3

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-28-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Tan-orange silty sand						
Auger refusal @ 2.3'						No water table encountered @ 0hrs
	5					

RECORD OF SUBSURFACE EXPLORATION

Boring B-4

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-27-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silt with fine sand						
Brown-orange sandy silt	5					
Tan-orange fine sand, trace silt						
Tan-gray and orange fine sand with silt, trace gravel	10					
Auger refusal @ 12.9'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-5

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-27-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange-tan fine sand with silt, trace gravel						
Orange-tan silty fine sand	5					
	10					
Auger refusal @ 15.1'	15					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-6

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-29-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange-brown silt, trace fine sand, trace clay						
Yellow silty fine sand, trace clay						
Orange silt with fine sand, trace clay	5					
Auger refusal @ 7.1'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-7

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-29-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown clayey silt with fine sand and organics						
Auger refusal @ 2.5'						No water table encountered @ 0hrs
	5					

RECORD OF SUBSURFACE EXPLORATION

Boring B-8

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-29-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silty sand with clay and organics						
Tan-yellow silty fine sand	5 10					
Red silty fine sand	15					
Pale gray clay silt						
Tan-yellow silty fine sand	20					
Auger refusal @ 21.7'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-9

SSI

Project Name: Proposed Spray Irrigation Site Date of Boring: 10-28-80

Site: St. Mary's Site, Sewanee, Tennessee Project No.: 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange silty fine sand, trace clay	5					
Yellowish-orange silt with fine sand, trace clay, grades back to orange fine sand with silt, trace clay	10 15					
Auger refusal @ 16.5'						No water table encountered @ 0hrs

SSI

RECORD OF SUBSURFACE EXPLORATION

Boring B-10

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-27-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange silt with clay and fine sand						
	5					
Yellow-tan silty fine sand	10					
Brown fine sand with silt						
Yellow-orange fine sand with silt	15					
Auger refusal @ 17.7'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-11

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-29-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Red silty sand, trace clay						
Orange sand with silt	5					
Yellow fine sand with silt						
Pale tan clay silt with sand	10					
Tan silty fine sand	15					
Brown silty sand						
Auger refusal @ 19.3'	20					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-12

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 11-6-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Orange-brown silt with sand and tan gravel						
Tan-orange sand with silt	5					
Brown-red sand with silt						
Tan-brown fine sand with silt						
Light brown silty sand	10					
Auger refusal @ 10.3'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-13

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-29-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Tan and yellow silty fine sand						
	5					
Auger refusal @ 9.0'	10					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-14

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-29-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silty sand						
Auger refusal @ 3.6'	5					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-15

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-29-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown sandy silt						
Yellow-tan silty fine sand						
Auger refusal @ 2.4'						No water table encountered @ 0hrs
	5					

RECORD OF SUBSURFACE EXPLORATION

Boring B-16

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-29-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Tan silty fine sand	5					
Auger refusal @ 5.4'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring [illegible]-17

Project Name: Proposed Spray Irrigation Site
Date of Boring: 10-29-80
Site: St. Mary's Site, Sewanee, Tennessee
Project No.: 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Yellow-tan clayey silt						
Brown silt with clay	5					
Gray clayey silt						
Brown clayey silt						
Gray silty clay	10					
Auger refusal @ 11.1'						No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-18

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-29-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown-orange sand with silt						
Orange and tan fine sand trace silt	5					
Auger refusal @ 9.3'	10					No water table encountered @ 0hrs

RECORD OF SUBSURFACE EXPLORATION

Boring B-19

SSI

Project Name: Proposed Spray Irrigation Site **Date of Boring:** 10-29-80

Site: St. Mary's Site, Sewanee, Tennessee **Project No.:** 472-05028

DESCRIPTION	DEPTH	ELEV.	SAMPLE	N	M_c	REMARKS
SURFACE						
Brown silt, trace clay						
	5					
Gray clayey silt						
	10					
Brown clayey silt						
	15					
Gray clayey silt						
Brown silt trace clay	20					
Auger refusal @ 21.1'						
						No water table encountered @ 0hrs

GENERAL NOTES

SAMPLE IDENTIFICATION

The Unified Soil Classification System is used to identify the soil unless otherwise noted.

SOIL PROPERTY SYMBOLS

N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch O.D. split-spoon.

Qu: Unconfined compressive strength, TSF

Qp: Penetrometer value, unconfined compressive strength, TSF

Mc: Water content, %

LL: Liquid limit, %

PI: Plasticity Index, %

δ_d: Natural dry density, PCF

▼: Apparent groundwater level at time noted after completion.

DRILLING AND SAMPLING SYMBOLS

SS: Split-spoon - 1 3/8" I.D., 2" O.D., except where noted.
ST: Shelby Tube - 3" O.D., except where noted.
AU: Auger sample.
DB: Diamond Bit.
CB: Carbide Bit.
WS: Washed Sample.

RELATIVE DENSITY AND CONSISTENCY CLASSIFICATION

TERM (NON-COHESIVE SOILS)	STANDARD PENETRATION RESISTANCE
Very Loose	0 - 2
Loose	2 - 4
Slightly Compact	4 - 8
Medium Dense	8 - 16
Dense	16 - 26
Very Dense	Over 26

TERM (COHESIVE SOILS)	Qu - (TSF)
Very Soft	0 - 0.25
Soft	0.25 - 0.50
Firm (Medium)	0.50 - 1.00
Stiff	1.00 - 2.00
Very Stiff	2.00 - 4.00
Hard	4.00 +

PARTICLE SIZE

Boulders	8 in. +	Coarse Sand	5mm-0.6mm	Silt	0.074mm-0.005mm
Cobbles	8 in.-3 in.	Medium Sand	0.6mm-0.2mm	Clay	-0.005mm
Gravel	3 in.-5mm	Fine Sand	02.mm-0.074mm		

APPENDIX B

"Evaluation of Potential Sites for Forest Spray Irrigation System - Sewanee, Tennessee" William E. Sopper, Environmental Scientist Consultant

SITE EVALUATION FOR PROPOSED FOREST SPRAY IRRIGATION SYSTEM

SEWANEE, TENNESSEE WASTEWATER FACILITY

Report Prepared
for
Gannett Fleming Corddry and Carpenter, Inc.
P.O. Box 1963
Harrisburg, Pennsylvania 17105

Prepared by: William E. Sopper
William E. Sopper
Environmental Scientist
Consultant

November 19, 1980

416 Outer Drive
State College, Pa. 16801

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SITE EVALUATION FOR PROPOSED FOREST SPRAY IRRIGATION SYSTEM

SEWANEE, TENNESSEE WASTEWATER FACILITY

INTRODUCTION

A study was conducted to determine the feasibility for disposal of treated wastewater by forest spray irrigation at the Sewanee, Tennessee Wastewater Treatment Facility. The specific objectives of the study were to evaluate the physical, chemical, and hydrologic properties of the soils on the potential sites in terms of their suitability for spray irrigation of wastewater. Field work was conducted during the period October 24-31, 1980.

SITE DESCRIPTION

The three sites evaluated are shown on Figures 1 and 2. The Rutledge Farm site is approximately 317 acres; the Garners Town site is approximately 90 acres; and the St. Marys site is approximately 75 acres. All sites are in forest cover (Oak-Hickory Forest Type). Predominant species are scarlet oak, black oak, white oak, chestnut oak, post oak, and hickory. Predominant understory species are dogwood, sassafras, black gum, red maple, and sugar maple.

The two major soil types present on the sites are the Hartsell soil type and the Muskingum soil type. These soils beong to the Hartsell-Muskingum-Cotaco Association typical of the Cumberland Plateau. The Hartsell soil type generally occupies undulating and rolling topography

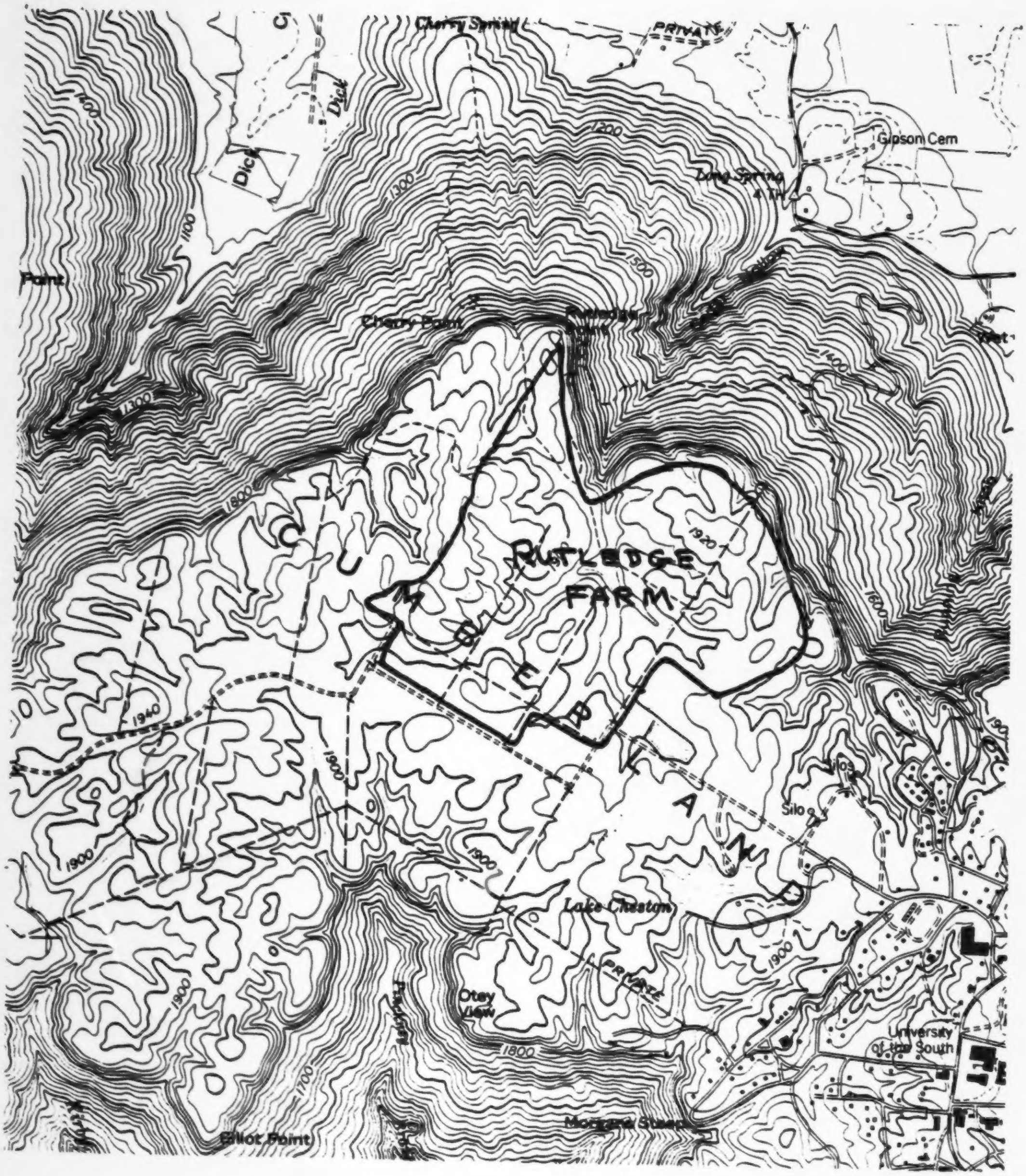
Cherry Spring
PRIVATE
Dick
Dick
Gipson Cem
Long Spring
Point
1200
1300
1100
1500
Cherry Point
Rutledge Point
1300
1800
1600
CUMBERLAND
RUTLEDGE FARM
1920
1940
1900
1900
1900
Silos
Silo
Lake Cheston
PRIVATE
1900
Otey View
1800
1700
1900
University of the South
Elliot Point
Morgans Steep

Figure 1. Location of Rutledge Farm Site.

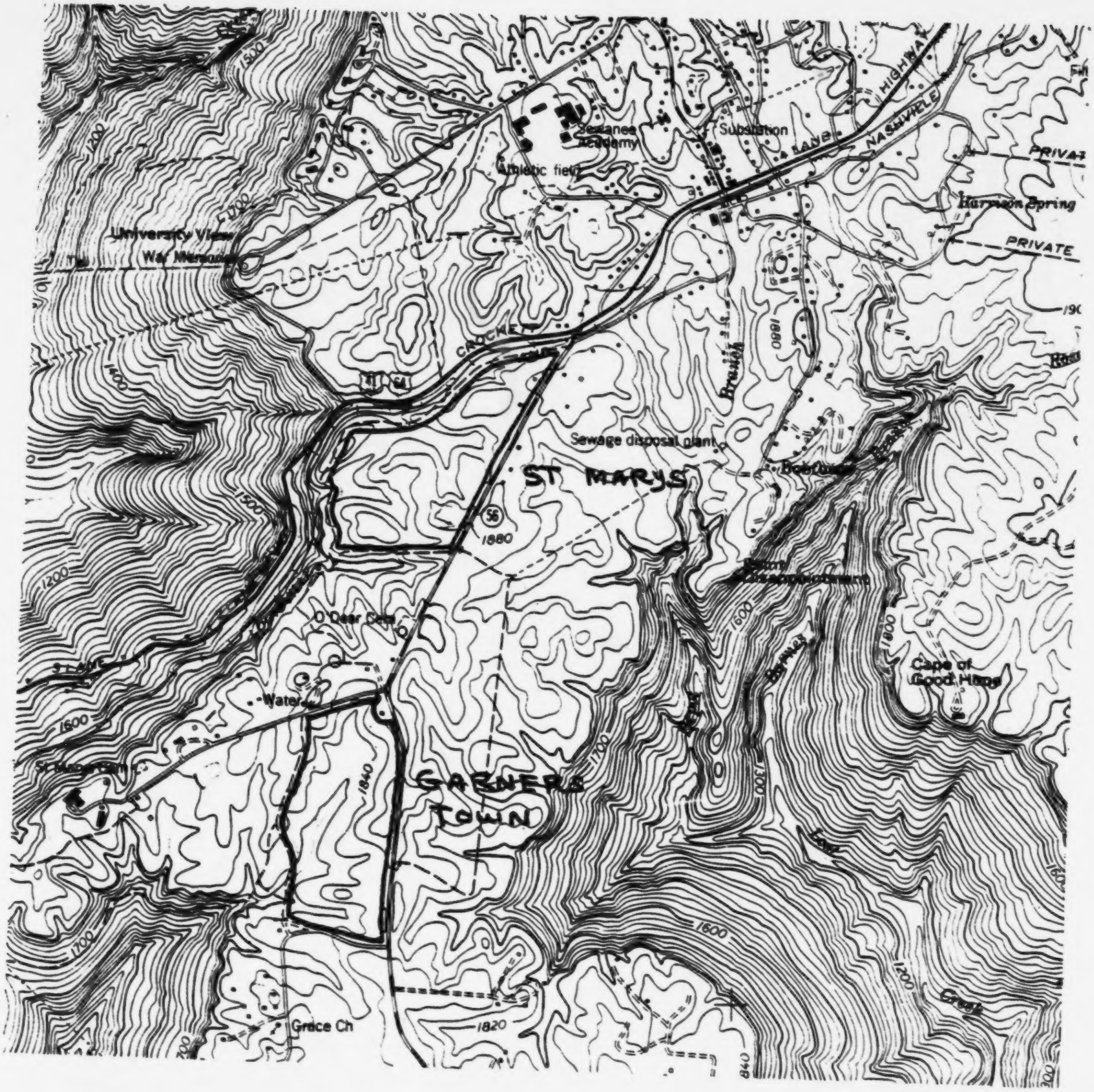
Sewanee Academy
Substation
Athletic field
HIGHWAY
NASHVILLE
LANE
PRIVATE
PRIVATE
Harrison Spring
University View
War Memorial
CROCKETT
41
64
Sewage disposal plant
ST MARYS
56
1880
O'Dear Dell
Water
GARNERS TOWN
1840
1820
Grace Ch
Cape of Good Hope
Creek
1200
1500
1600
1700
1800
1300

Figure 2. Location of St. Marys and Garners Town Sites.

with slopes ranging from 2 to 12 percent. They are well drained with a depth of 2 to 6 feet to bedrock. They are a fine sandy loam in texture, are strongly acid, and are low in plant nutrients and organic matter. The Muskingum soil type generally occurs in large areas along drainageways and on steep areas near the edge of the escarpment with slopes ranging from 12 to 25 percent. They are good to excessively drained with depth to bedrock varying from 1 to 4 feet. They are classified as having a stony fine sandy loam texture. They are strongly acid and are low in plant nutrients and organic matter. Typical profiles as described in the 1958 SCS soil survey are given in Table 1. The actual soil profiles were much deeper (in some cases, over 20 feet) on the three sites evaluated as indicated in the SSI report.

There is a well-developed forest floor on all sites ranging from 1 to 2 inches in depth. This thick organic litter layer would be beneficial for a spray irrigation system in that it provides a protective cover for the soil, maintains high soil infiltration rates, and provides additional water storage capacity.

SITE EVALUATION

Collection of Soil Samples for Chemical Analyses

Soil samples were collected from all three sites. On each site, samples were collected at six random locations which were representative of the entire area. Pits were excavated and soil samples were collected from the A and B horizons of each soil type. These samples were analyzed for pH, cation exchange capacity, concentrations of P, K, Ca, and Mg, and percent saturation for K, Ca, and Mg. Separate soil samples were collected for the analyses of trace metals. These samples were collected at the 0-6, 6-12, and 12 to 24 inch depth. All soil samples collected for

Table 1. Typical Hartsell and Muskingum Soil Profile

Classification: Typic Hapludults

Horizon	Depth (inches)	Description
Hartsell Soil Type		
A1	0-1	Dark grey loam; weak medium granular structure; very friable; 3 percent coarse fragments; abrupt smooth boundary.
A2	1-7	Yellow brown fine sandy loam; weak medium subangular blocky structure; friable; 4 percent coarse fragments; clear wavy boundary.
B21	7-17	Yellow brown fine sandy loam; weak medium subangular blocky structure; friable; 3 percent coarse fragments; gradual wavy boundary.
B22	17-24	Yellow brown very fine sandy loam; moderate medium and coarse subangular blocky structure; very friable; 2 percent coarse fragments; gradual wavy boundary.
C	24-31	Yellowish brown sandy loam; moderate medium subangular blocky structure; friable; 10 percent coarse fragments; abrupt wavy boundary.
Muskingum Soil Type		
A	0-8	Pale brown to yellow brown loose very friable stony fine sandy loam.
B	8-18	Light yellowish-brown friable stony fine sandy loam; very weak medium blocky structure.
C	18+	Sandstone bedrock or very stony sandstone residum.

Reference: Soil Conservation Service, 1958. Soil Survey, Franklin County, Tennessee, U.S. Department of Agriculture.

chemical analyses were air dried and sieved to pass a 10 mech (2 mm) screen.

Collection of Undisturbed Soil Samples for Hydrologic Analyses

Undisturbed soil samples were collected on each site with a Uhland soil sampler for laboratory measurements of percolation capacity and water storage capacity. Samples were collected from each of the two soil types at six random locations on each site. Each soil core collected was 3 inches in diameter and 3 inches deep with a total soil volume of 21 cubic inches. Samples were collected so as to be representative of the three major soil horizons (A, B, and C) in each soil type. Samples were taken at the 0-3, 15-18, and 24-27 inch depth.

Field Measurements of Infiltration Capacity

The potential of the soil for both infiltration and percolation is of great importance in terms of suitability of a site and for determination of the wastewater application rate. Infiltration capacity is defined as the rate at which water enters the soil surface (0-1 inch depth) and is normally expressed in terms of inches per hour. The rate varies with moisture content of the soil and wetting time. Measurements should be made under conditions similar to those expected during operation. For wastewater spray irrigation systems, infiltration measurements should be made with the soil at so-called "field capacity." Under this steady-state condition, all free gravity water has drained from the non-capillary soil pores and the only soil moisture remaining is that held within the capillary pores which can only be removed by evaporation and transpiration. Standard soil survey reports published by the Soil Conservation Service do not provide data on soil infiltration capacity because infiltration rates are highly dependent upon vegetation cover type and land management practices and are usually site specific.

Infiltration measurements were made with a double-ring infiltrometer according to standard Soil Conservation Service methods. Twenty-four measurements were made on the Muskingum soil type and 36 measurements were made on the Hartsell soil type. Three measurements of infiltration were made at each location. A 3.5-inch head of water was added to the infiltrometer for each measurement. The time required for the 3.5-inch depth of water to infiltrate was recorded with a stop watch. These data were then converted to a rate expressed in inches per hour. Before each infiltration measurement was made, water was added to the infiltrometer and allowed to infiltrate into the soil until a steady-state was reached. This initial wetting eliminates variations in antecedent soil moisture conditions and creates a moist soil condition more representative of a spray irrigation system.

Results of the infiltration measurements are given in Tables 2 and 3. The data indicate that the infiltration capacities of both soil types are extremely high. Average infiltration capacity for the Hartsell soil type was 27 inches per hour and for the Muskingum soil type was 29 inches per hour. It is quite obvious that the infiltration capacity of both soils is more than adequate for the proposed spray irrigation system and should pose no restrictions on application rates.

Field Measurements of Percolation Capacity

Percolation capacity is defined as the vertical movement of water within the soil profile above the saturated zone (water table). It is influenced by soil texture, structure, bulk density, porosity, and moisture

Table 2. Infiltration Capacity of the Hartsell Soil Type

Site	Test	Infiltration Capacity
		inches per hour
Garners Town	1	28
	2	58
	3	7
	4	27
	5	60+
	6	32
	7	15
	8	10
	9	10
St. Marys	10	32
	11	18
	12	16
	13	38
	14	60+
	15	10
	16	22
	17	9
	18	12
Rutledge Farm	19	20
	20	22
	21	48
	22	60+
	23	11
	24	39
	25	25
	26	19
	27	28
	28	39
	29	18
	30	40
	31	24
	32	20
	33	16
	34	14
	35	55
	36	27
Average		27

Table 3. Infiltration Capacity of the Muskingum Soil Type

Site	Test	Infiltration Capacity
		inches per hour
Garners Town	1	25
	2	50
	3	15
	4	60+
	5	41
	6	19
	7	35
	8	20
	9	37
	10	60+
	11	60+
	12	20
	13	23
	14	21
	15	18
St. Marys	16	2
	17	3
	18	51
	19	18
	20	18
	21	39
	22	20
	23	17
	24	32
Average		29

content. Standard percolation tests are not applicable for spray irrigation sites. Normal percolation tests allow for both vertical and lateral movement of water. Such results are not applicable for a spray irrigation site were the entire area will be wetted and the critical parameter is vertical movement of water under high soil moisture conditions.

Field measurements were made of the percolation capacity of the three major soil horizons of both soil types on all three sites. Measurements were made at the 2, 15, and 24 inch soil depth. At the 2-inch soil depth measurements were made with a 4-inch diameter aluminum pipe which was driven into the subsoil horizon approximately three inches. The pipe was filled with 600 cc of water (3-inch depth) and allowed to reach a steady-state condition. After steady-state conditions were reached, water was again added to bring the water level up to the original depth of 3 inches. For measurements at the 15 and 24 inch depth, a 2-inch bucket auger was used to excavate a hole for insertion of a 2-inch aluminum pipe. This pipe was similar driven into the subsoil horizon approximately 3 inches. Initial wetting procedures were the same as described above. Measurements of the water level drop in the aluminum tubes were made at 10 to 15 minute intervals. These data were then converted to express the percolation rate in terms of inches per hour. Results are given in Tables 4 to 6. Percolation rates for both soil types are quite high. Results indicate that the percolation rates of both soil types down to a depth of 24 inches is more than adequate for a spray irrigation system and should pose no restrictions on application rates. As expected, the lowest permeability was found at the 24-inch depth. However, even at this depth the percolation rate in both

Table 4. Field Measurements of Percolation Capacity of the Hartsell Soil Type

Site	Test	Percolation Capacity		
		- - -Soil Depth (inches)- - -		
		2	15	24
		-.- - - inches per hour - - - -		
Garners Town	1	12.7	4.5	0.80
	2	17.8	2.9	0.24
	3	1.9	0.63	4.6
St. Marys	4	8.2	0.24	0.72
	5	4.0	1.7	1.7
	6	5.0	0.96	2.6
Rutledge Farm	7	9.6	1.7	1.4
	8	5.5	2.6	1.4
	9	9.6	1.7	2.4
	10	9.1	5.3	2.6
	11	2.2	5.8	0.24
	12	13.7	6.2	1.4
Average		8.3	2.9	1.7

Table 5. Field Measurements of Percolation Capacity of the Muskingum Soil Type

Site	Test	Percolation Capacity		
		- - - Soil Depth (inches) - - -		
		2	15	24
		- - - - inches per hour - - - -		
Garners Town	1	6.0	1.2	1.2
	2	18.4	3.1	1.9
	3	27.2	2.2	1.2
	4	24.0		
	5	13.8		
	6	7.4		
	7	8.4		
	8	18.4		
	9	12.0		
	10	22.2		
	11	12.8		
	12	20.3		
	13	6.0		
	14	38.4		
St. Marys	15	0.72	1.4	1.2
	16	7.7	1.4	2.4
	17	17.5	0	0.24
Average		15.4	1.5	1.3

Table 6. Percolation Capacity of the Hartsell and Muskingum Soil Types

Soil Type	Soil Horizon	Soil Depth	Percolation Capacity Average	Range
		inches	inches per hour	
Hartsell	A	2	8.3	1.9 -17.8
	B	15	2.9	0.63- 5.8
	C	24	1.7	0.24- 4.6
Muskingum	A	2	15.4	0.72-38.4
	B	15	1.5	0 - 3.1
	C	24	1.3	0.24- 2.4

soil types exceeded one inch per hour. The SSI report indicates that the average soil mantle depth is much greater than the 2 to 6 feet expected. The greater soil depth will provide additional water storage capacity.

LABORATORY RESULTS

Soil Percolation Capacity

The undisturbed soil cores collected were used to determine percolation capacity on a constant-head permeameter under laboratory conditions. Soil samples were first saturated by placing them in a pan with one inch of standing water and allowing them to absorb water for 24 hours. After the initial 24-hour soaking period, the water level was raised slowly until it reached the top of the 3-inch sample cylinders. This procedure allowed the soil cores to become saturated with water from the bottom thus forcing out any entrapped air. The saturated samples were then placed on the permeameter with a constant head of one inch of water. Percolate draining from the bottom of the soil cores was collected and the volume measured in cubic centimeters at 15-minute intervals. Results were converted to express percolation rate in inches per hour. Results are given in Table 7 and 8. For the Harsell soil type, the average percolation capacity for the A Horizon (0-3 inch depth) was 6.4 inches per hour, for the B Horizon (15-18 inch depth) was 2.2 inches per hour and for the C Horizon (24-27 inch depth) it was 1.1 inches per hour.

For the Muskingum soil type the average percolation rates were 9.5 inches per hour for the A Horizon (0-3 inch depth), 1.1 inches per hour

Table 7. Laboratory Measurements of Percolation Capacity of the Hartsell Soil Type

Site	Test	Percolation Capacity - - - - Soil Depth (inches) - - - 0-3	 15-18	 24-27
			inches per hour	
Garners Town	1	8.9	2.8	0.7
	2	11.4	2.5	0.3
	3	1.3	0.3	--
St. Marys	4	6.6	0.4	0.7
	5	3.2	1.5	1.9
	6	4.7	1.0	--
Rutledge Farm	7	8.2	1.9	1.1
	8	4.2	2.8	1.7
	9	7.1	1.3	2.0
	10	7.8	4.1	1.9
	11	2.3	3.4	0.4
	12	11.4	4.4	0.9
Average		6.4	2.2	1.1

Table 8. Laboratory Measurements of Percolation Capacity of the Muskingum Soil Type

Site	Test	Percolation Capacity - - - Soil Depth (inches) - - - 0-3	 15-18	 24-27
			inches per hour	
Garners Town	1	5.4	1.0	0.8
	2	12.1	2.4	--
	3	17.9	1.5	1.0
St. Marys	4	1.0	1.3	--
	5	6.0	1.2	--
	6	14.8	0.6	--
Average		9.5	1.1	0.9

for the B Horizon (15-18 inch depth), and 0.9 inch per hour for the C Horizon (24-27 inch depth). The SCS soil survey report indicates that the permeability of this soil type can range from 6.0 to 50 inches per hour.

Results of the field and laboratory measurements of percolation rates were quite similar. Average percolation rates measured in the laboratory were lower than those measured in the field. The low percolation rates measured on the undisturbed samples in the laboratory was probably due to compaction of the samples. It was extremely difficult to collect the soil cores particularly for the lower subsoil horizons. Considerable pounding with the Uhland sampler drop hammer was necessary to drive the cutting bit three inches deep. As a result some compaction probably occurred. The field measurements are probably more indicative of actual percolation rates for this soil horizon.

Soil Water Storage Capacity

The undisturbed soil cores were also used in the laboratory to determine total water storage capacity for each of the three major soil horizons in each soil type. Each soil core sample was weighed immediately after saturation. Samples were then place on dry blotter paper and allowed to drain for 48 hours. During this interval all water held in noncapillary pores drains from the sample allowing the soil moisture to reach the "field capacity" state. Sample cores were covered with aluminum foil to prevent moisture loss by evaporation. At the end of the 48-hour period the samples were again weighed. All samples were then allowed to reach an air-dry steady-state condition. This required 7 to 10 days. Final air-dry sample weights were recorded. The weight difference measured in grams is

Table 9. Detention Water Storage Capacity of the Hartsell Soil Type

Site	Test	Detention Water Storage Capacity - - - Soil Depth (inches) - - - 0-3	15-18	24-27
		inch of water/inch soil		
Garners Town	1	0.28	0.26	0.22
	2	0.24	0.22	0.20
	3	0.24	0.30	--
St. Marys	4	0.23	0.18	0.18
	5	0.30	0.27	0.19
	6	0.27	0.23	--
Rutledge Farm	7	0.27	0.30	0.20
	8	0.15	0.26	0.20
	9	0.23	0.26	0.15
	10	0.25	0.28	0.15
	11	0.28	0.29	0.15
	12	0.25	0.32	0.14
Average		0.25	0.26	0.18

Table 10. Detention Water Storage Capacity of the Muskingum Soil Type

Site	Test	Detention Water Storage Capacity - - - Soil Depth (inches) - - - 0-3	 15-18	 24-27
			inch of water/inch soil	
Garners Town	1	0.25	0.26	0.15
	2	0.29	0.23	—
	3	0.22	0.25	0.19
St. Marys	4	0.20	0.20	--
	5	0.25	0.24	0.14
	6	0.26	0.21	0.20
Average		0.25	0.23	0.17

Table 11. Retention Water Storage Capacity of the Hartsell Soil Type

Site	Test	Retention Water Storage Capacity - - - Soil Depth (inches) - - - 0-3	15-18	24-27
		inch of water/inch soil		
Garners Town	1	0.18	0.21	0.20
	2	0.20	0.19	0.18
	3	0.18	0.19	--
St. Marys	4	0.25	0.25	0.22
	5	0.19	0.24	0.23
	6	0.21	0.21	--
Rutledge Farm	7	0.20	0.18	0.19
	8	0.22	0.21	0.21
	9	0.20	0.20	0.22
	10	0.20	0.21	0.21
	11	0.18	0.19	0.22
	12	0.23	0.23	0.20
Average		0.20	0.21	0.21

Table 12. Retention Water Storage Capacity of the Muskingum Soil Type

Site	Test	Retention Water Storage Capacity Soil Depth (inches) 0-3	15-18	24-27
		inch of water/inch soil		
Garners Town	1	0.21	0.20	0.17
	2	0.19	0.21	--
	3	0.19	0.20	0.20
St. Marys	4	0.25	0.23	--
	5	0.19	0.23	0.16
	6	0.20	0.22	0.22
Average		0.21	0.22	0.19

an indication of water loss from a saturated condition to field capacity and to an air dry condition. The weight loss was converted to a volume basis and then expressed in terms of inches depth of water storage. The amount of transitory water storage between saturation and field capacity is called detetion storage and the amount of water stored between the field capacity state and the air-dried state is called retention storage.

Average detention water storage capacity for the Hartsell soil type was 0.25 inch of water/inch soil for the A Horizon (0-3 inches), 0.26 inch of water/inch soil for the B Horizon (15-18 inches), and 0.18 inch of water/inch soil for the C Horizon. For the Muskingum soil type, the average water storage capacity was 0.25 inch of water/inch soil for the A Horizon, 0.23 inch of water/inch soil for the B Horizon, and 0.17 inch of water/inch soil for the C Horizon. Detention water storage capacity was quite similar for both soil types. There was no significant differences between sites. Similar results were obtained for retention water storage capacity.

A summary of soil physical and hydrological properties is given in Table 13. This information should be used to design the spray irrigation system, to determine irrigation application rates, and to develop the system operational manual. The surface soil infiltration capacity is more than adequate for the proposed spray irrigation system and should present no constraints on application rates. Average permeability of the C Horizon (24-27 inch depth) ranged from 0.9 to 1.1 inches per hour from the laboratory measurements and 1.3 to 1.7 inches per hour from the field measurements and should not pose any design restrictions. The most limiting factor appears to be the permeability of the C Horizon (24 to 27 inch depth).

Table 13. Summary of Soil Physical and Hydrologic Data

Parameter	A Horizon	B Horizon	C Horizon
	Hartsell Soil Type		
Average horizon depth (inches)	0-7	7-24	24-31
Infiltration capacity (inches/hr)	27	--	--
Field percolation capacity (inches/hr)	8.3	2.9	1.7
Lab percolation capacity (inches/hr)	6.4	2.2	1.1
Detention water storage capacity (inches of water/inch soil)	0.25	0.26	0.18
Retention water storage capacity (inches of water/inch soil)	0.20	0.21	0.21
Total water storage capacity for average horizon depth (inches)	3.1	8.0	2.7

Parameter	A Horizon	B Horizon	C Horizon
	Muskingum Soil Type		
Average horizon depth (inches)	0-8	8-18	18-27
Infiltration capacity (inches/hr)	29	--	--
Field percolation capacity (inches/hr)	15.4	1.5	1.3
Lab percolation capacity (inches/hr)	9.5	1.1	0.9
Detention water storage capacity (inches of water/inch soil)	0.25	0.23	0.17
Retention water storage capacity (inches of water/inch soil)	0.21	0.22	0.19
Total water storage capacity for average horizon depth (inches)	3.7	4.5	3.2

Note: Data reported here are representative of the soil depths evaluated for hydrologic properties in the field. Greatest depth evaluated was 24 to 27 inches. The data are presented in a form to characterize the typical soil horizons as described in the SCS soil survey. Thus, the water storage capacity values are very conservative. As stated previously, the SSI report indicates that the soil mantle on all three sites is much deeper than the 27 and 31 inches shown in this Table.

Both soil types have a high total water storage capacity. The Hartsell soil type has a total water storage capacity of 13.8 inches for the 0 to 31 inch soil depth. The Muskingum soil type has a total water storage capacity of 11.4 inches of water for the 0 to 27 inch soil depth.

More important is the fact that detention water storage capacity in both soil types is over 50 percent. (Harsell soil type - 53%; Muskingum soil type - 51%). This is extremely important in the design of a spray irrigation system since this is rapidly created storage (water storage created within 24 to 72 hours). As stated earlier, the deeper soil mantle, up to 33.3 feet, reported by SSI will provide even greater water storage.

Soil Chemical Analyses

Results of the analysis for soil pH, cation exchange capacity, and selected nutrients are given in Table 14 and 15. The soil is slightly acidic in nature. The phosphous content is extremely low. The percent saturation for a balanced soil should fall within these ranges:

K - 2 to 5%
Mg - 10 to 25%
Ca - 60 to 80%

It is quite obvious from the results of the analyses that both soils are deficient in nutrients in terms of a balance soil.

The cation exchange capacity (CEC) of the soil is the best parameter which relates quantitatively to the ability of soil to bind trace metals. The CEC of both horizons in both soil types are relatively high, ranging from 7.9 to 11.3. This is desirable since it indicates a high potential for binding a trace metals in the soil.

Table 14. Analyses of Soil Samples for the Hartsell Soil Type

Constituent	A Horizon	B Horizon
Soil pH	5.0	5.0
Buffer pH	6.3	6.4
P (μg/g)	17	17
K (meq. per 100 g)	0.19	0.13
Ca (meq. per 100 g)	0.3	0.2
Mg (meq. per 100 g)	2.3	1.1
Cation exchange capacity (CEC)	10.2	7.9
Percent saturation (K)	1.6	1.6
Percent saturation (Mg)	3.5	3.4
Percent saturation (Ca)	21.1	16.0

Table 15. Analyses of Soil Samples for the Muskingum Soil Type

Constituent	A Horizon	B Horizon
Soil pH	5.4	5.2
Buffer pH	6.5	6.4
P (μg/g)	18	14
K (meq. per 100 g)	0.15	0.11
Ca (meq. per 100 g)	0.3	0.3
Mg (meq. per 100 g)	3.0	1.9
Cation exchange capacity (CEC)	10.5	8.9
Percent saturation (K)	2.0	1.3
Percent saturation (Mg)	4.6	3.9
Percent saturation (Ca)	34.3	24.5

The soil samples for trace metal constituents were extracted with 0.1 N hydrochloric acid and the extract analyzed for Cu, Zn, Cr, Pb, Co, Cd, and Ni by standard atomic absorption spectroscopy. The results of these analyses are given in Table 16.

The normal range of trace metal concentrations found in soils are given in Table 17. A comparison of these two tables indicates that the concentration of trace metals found in both soil types prior to spray irrigation is well below that normally found in soils.

Table 16. Extractable[1] Trace Metal Analyses of Soil Samples Collected on the Hartsell and Muskingum Soil Types

Soil Type	Soil Depth	Cu	Zn	Cr	Pb	Co	Cd	Ni
	inches				µg/g			
Hartsell[2]	0-6	0.52	2.65	0.09	5.43	0.52	0.033	1.04
	6-12	0.37	1.29	0.09	2.58	0.41	0.021	0.83
	12-24	0.31	0.71	0.06	2.63	0.41	0.014	0.78
Muskingum[3]	0-6	0.36	1.98	0.07	3.70	0.51	0.026	0.87
	6-12	0.33	0.95	0.06	2.33	0.44	0.019	0.82
	12-24	0.33	0.63	0.06	2.15	0.48	0.013	0.69

[1] 0.1N HCL extraction

[2] Means based on 10 samples per depth

[3] Means based on 6 samples per depth

Table 17. Normal Range of Trace Metal Concentrations Found in Soils

	Normal Range in Soils	Mean All Soils
	μg/g	μg/g
Cu	2-100	20
Zn	10-300	50
Cr	5-1000	200
Pb	2-200	10
Co	1-40	8
Cd	0.01-7.0	0.50
Ni	5-500	40

SUMMARY AND CONCLUSIONS

An evaluation was made of three sites owned by the University of the South, Sewanee, Tennessee to determine the suitability for spray irrigation of wastewater. The sites consisted of two major soil types and are predominantly forested. The specific sites evaluated were St. Marys, Garners Town, and the Rutledge Farm. The general topography is level to gently sloping (less than 15 percent slope) and generally suitable for a spray irrigation system. The study included an evaluation of the physical, chemical, and hydrological properties of each soil type. Results indicated that the physical and hydrological properties of the soils were quite acceptable for a spray irrigation system. Results indicate that application rates up to 3 inches per week would be feasible. Results of the chemical analyses of the soils indicate that nutrient levels of the soils are extremely low and all sites would benefit from the application of the wastewater. In all probability tree growth would be greatly increased. Concentrations of trace metals in the soils are extremely low and thus application of wastewater, with low concentrations of trace metals, would not pose any problems in terms of phytotoxicity to vegetation or degradation of soil percolate or groundwater quality.

The results of the study indicate that all sites are suitable for the proposed spray irrigation of treated wastewater. The Rutledge Farm site is probably the most suitable site on the bases of location, topography, and physical, chemical, and hydrologic soil properties. However, it is the most distant site from the wastewater treatment plant and an economic evaluation would probably eliminate this site.

*U.S. Government Printing Office 1981: 744-096